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Cover: A Coyote, *Canis latrans*, and Badger, *Taxidea taxus*, observed together approximately 5 km north of Cypress Hills Provincial Park, Alberta. See note by Kiliaan, Mamo, and Paquet, pages 122-123. Photograph courtesy Hendrik P. L. Kiliaan.

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Distribution and Ecology of Six Rare Species of Prairie Rodents in Manitoba

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Range extensions, habitat selection, abundance, and reproduction are detailed for six rare species of prairie rodents in southern Manitoba. The ranges of the Olive-backed Pocket Mouse, Prairie Vole, Northern Grasshopper Mouse, and Western Jumping Mouse are highly localized at this northern periphery of their distribution, with disjunct populations apparently related to the contraction of xeric mixed-grass prairie during the last 6000 years. The Plains Pocket Gopher, a tall-grass prairie species, is found in Canada only in a restricted area south of the Roseau River region, and is surrounded on three sides by populations of the Northern Pocket Gopher. The Fox Squirrel first invaded Canada in the early 1970s and its rapid expansion throughout southern Manitoba and adjacent Saskatchewan is correlated to the increased availability of corn – a favorite and dependable source of food.

Key Words: Fox Squirrel, *Sciurus niger*, Plains Pocket Gopher, *Geomys bursarius*, Olive-backed Pocket Mouse, *Perognathus fasciatus*, Prairie Vole, *Microtus ochrogaster,* Northern Grasshopper Mouse, *Onychomys leucogaster,* Western Jumping Mouse, *Zapus princeps*, prairie rodents, distribution, abundance, habitat, reproduction, Manitoba.

Approximately 10 000 years ago, a warm-dry trend in climate began a shift in the vegetation of southwestern Manitoba from coniferous forest and tundra to prairie and groves of deciduous trees. Over the next 4000 years, prairie continued to expand, reaching a northern limit almost to The Pas. Probably most recent mammal representatives of the Grassland Biome entered the province during this period. As early as 6000 years ago in some areas, and certainly by 3000 years ago over the whole southwestern region, aspen parkland appeared on the uplands and mixed deciduous forest extended along stream valleys and other favorable locations, reflecting a modest return to cooler and wetter conditions. This contraction of prairie habitat must have profoundly affected the distribution and abundance of grassland mammals. Indeed, the fluctuations in climate and vegetation appear to explain the highly localized and disjunct distributional patterns presently displayed by a number of small mammals at the northern edge of their range in southwestern Manitoba (Shay 1984; Lammers and Wrigley 1984).

During the last century, mixed-grass and tall-grass prairie and aspen parkland have been transformed into grain fields and pastures through concentrated agricultural practices, leaving limited habitats (parks, edges of fields and forests, roadsides, abandoned lands) available for wildlife. This paper examines the distribution and ecology of six species of rodents classified as rare in this prairie region of Manitoba: Fox Squirrel (*Sciurus niger*), Plains Pocket Gopher (*Geomys bursarius*), Olive-backed Pocket Mouse (*Perognathus fasciatus*), Prairie Vole (*Microtus ochrogaster*), Northern Grasshopper Mouse (*Onychomys leucogaster*), and Western Jumping Mouse (*Zapus princeps*).

Methods

Specimens and data were gathered during a provincial survey of mammals initiated in 1970 and continued periodically to 1988. Each of the six species received special attention, since so little was known about them. Mice were collected with Museum Special mouse traps, baited with a mixture of peanut butter, bacon fat, and rolled oats. Rows of 65 traps were set for one to three nights in appropriate habitats, with traps about 7 m apart under vegetative cover or at the nearest hole. While a few Olive-backed Pocket Mice were

taken in traps, this method failed to reveal their actual abundance. Consequently, considerable effort was directed to catching these tiny rodents by hand. The procedure entailed walking after dark through stubble grain fields, sandy pastures, and along weedy roadways. One person carried a bright lantern flanked by several "catchers" who, after some practice, were able to capture by hand almost every pocket mouse that was discovered. A few Grasshopper Mice and Deer Mice were also obtained in this manner. Plains Pocket Gophers were collected by placing Macabee gopher traps inside the animals' tunnels. Fox Squirrels were either observed alive, picked up as roadkills, or collected by local residents. All reports and specimens are in the collections of the Manitoba Museum of Man and Nature.

Species Accounts

FOX SQUIRREL, *Sciurus niger*

The Fox Squirrel invaded southern Canada as recently as the early 1970s (Wrigley et al. 1973). In 1972, a roadkilled squirrel was picked up 8.8 km west of St. Claude, Manitoba – the first non-introduced Canadian record. Since then, 20 specimens and eight observations have been turned in by the public, a Museum volunteer, and staff of the Manitoba Department of Natural Resources. These records suggest an initial influx into south-central Manitoba from North Dakota (Hibbard 1956), and a subsequent rapid expansion north to Riverton (by 1977), east to the Red River Valley (1981) and Steinbach (1982), and west to the Saskatchewan border (1981). Eighty per cent of the records are from 1980 to 1985, which indicates not only greater public and official awareness of the animal's presence in Manitoba, but also a rapidly increasing and dispersing Fox Squirrel population. Other locality records include Morris, Glenlea, Mariapolis, Boissevain, Morden, Pierson, Lyleton, McCreary, Grand Beach, and Winnipeg.

In 1979, C. I. G. Adam contacted REW about possible sightings of a Fox Squirrel in Regina, Saskatchewan. In the succeeding five years, two specimens were taken at Oxbow and Stone Creek, and observations were reported from Regina, Osage, and the Souris River Valley as far west as Estevan and Weyburn (Adam 1984). Riparian deciduous forests along the Souris, Assiniboine, and perhaps the Qu'Appelle rivers appear to have been the dispersal routes followed by the squirrels in the invasion of southeastern Saskatchewan from Manitoba and North Dakota. This species has also spread to central and southeastern Montana via the forests of Manitoba Maple (*Acer negundo*), Green Ash (*Fraxinus pennsylvanica*), Cottonwood (*Populus trichocarpa*), and willow (*Salix* sp.) bordering the Yellowstone and Little Missouri (by 1971) rivers (Lampe et al. 1974).

Observations in Manitoba confirmed the Fox Squirrel's well-known habitat preference of deciduous forest edge and its excursions into nearby fields. In contrast, the Gray Squirrel was frequently found in dense forest and seldom foraged on the ground at any great distance from the safety of trees (our observations and Seton 1953). Both species are now found in the City of Winnipeg. Fox Squirrels were reported living in Bur Oak (*Quercus macrocarpa*) – Manitoba Maple – American Elm (*Ulmus americana*) forest, oak-maple forest, oak grove, aspen (*Populus tremuloides*) grove, open farmland, and open rangeland. A specimen from Riverton (the northern record for the species) was taken in a row of White Spruce (*Picea glauca*) trees in open agricultural land at the southern periphery of the boreal coniferous forest. A number of reports indicated that the squirrels were out in fields (up to 150 m) foraging for spilled corn and raiding corn and wheat bins. Others were seen feeding on acorns and rose hips at the forest edge.

An examination of grain-corn production in southern Manitoba (personal communication, John Rogalsky, Manitoba Department of Agriculture) showed an average annual planting of 1678 ha (range of 1012 to 2429) from 1960 to 1970 and a rapid rise from 1971 to 1984, averaging 36 556 ha (range of 2024 to 91 093). The sudden appearance and spread of Fox Squirrels in southern Manitoba since the early 1970s appear to be correlated to the increased availability of corn – a dependable and favorite source of food for the squirrels.

Of the 20 specimens of Fox Squirrels obtained, 9 were females and 11 were males. Little information on the breeding season could be gleaned from them, since all but one were collected from September to February – mainly outside the reproductive season. One female appeared to be approaching estrus (the uterus was swollen) on 6 February, and males taken on 20 January and 13 March had enlarged testes. We received a photograph of two Fox Squirrels in a mating chase through the trees in a backyard in Boissevain on 20 February. Seven females were non-breeding from 26 September to 19 January, while another showed old placental scars on 18 October. In Regina, Saskatchewan, Adam (1984) reported an adult Fox Squirrel accompanied by three subadults (almost full grown) on 30 April – the first evidence of breeding for that province. In the northern United States, male squirrels are in breeding condition from November to July and young can be born in any month from February to September. However, there are two main mating

FIGURE 1. Trapped Plains Pocket Gopher at its burrow near Ridgeville, Manitoba (R. E. Wrigley).

peaks, December to January and April to June (Jones et al. 1983). We suspect there are also two litters produced annually in Manitoba, with most mating occurring in February-March and June-July, and births in March-April and July-August.

PLAINS POCKET GOPHER, *Geomys bursarius*.

In 1911, H. Douthitt collected two specimens of the Plains Pocket Gopher (Figure 1) at the border town of Emerson, Manitoba – the first records for Canada. They are catalogued in the United States National Museum and were referred to by Bailey (1926) in his biological survey of North Dakota. Soper (1944) collected an additional ten specimens in an area 18.4 km (11.5 mi) ENE of Emerson. Wrigley and Dubois (1973) added another 29 specimens and delineated the range south of the Roseau River, and bounded on the east, north, and west by populations of the Northern Pocket Gopher (*Thomomys talpoides*). With the assistance of M. Oberpichler, we have now accumulated a total of 147 specimens taken in sand, rich loam, and to a limited extent, glacial till. This area was formerly tall-grass prairie and deciduous forest, but is now heavily cultivated. Most pocket gophers were restricted to abandoned land, the edges of farm fields, and the banks of roads (Figure 2), railroads, and drainage ditches. Extensive areas were uninhabited, presumably because the low relief of the land provided no burrow sites protected from the excess water that frequently floods these lowlands in spring, or because of low aeration of clay soils present in the Red River Valley. Downhower and Hall (1966) reported that in Kansas this species inhabited soils with at least 40 percent sand, and avoided poorly aerated soils of silt and clay. In Manitoba, fields of alfalfa and hay were much preferred over cereal crops and fallow. The number of pocket gophers inhabiting some crop fields such as alfalfa was remarkable. Large mounds of earth were scattered everywhere, even into hard-packed gravel roads. One farmer mentioned he had trapped hundreds in his alfalfa fields over the past four years, and other farmers regularly destroyed 11 to 50 per year, though with little effect.

Detailed distribution records are not provided here because of the large number of collecting sites. However, the species has been found in the vicinity of the following villages: Emerson, Fredensthal, Gardenton, Green Ridge, Overstoneville, Ridgeville, Roseau River, Stuartburn, Tolstoi, Woodmore, Senkiw, and New Rosa. We found recently that the species has crossed north over the Roseau River, perhaps forcing out the Northern Pocket Gopher. The new northern record for the Plains Pocket Gopher is 0.5 km N, 6.6 km W New Rosa. The species is presently classified as rare by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

This species produces only one litter per year in Manitoba, though two are possible in the southern part of the range (Nowak and Paradiso 1983). Males showed enlarged testes (length of 10 to 20 mm) from 14 April to 26 June. We lack

FIGURE 2. About 75 earth mounds made by several Plains Pocket Gophers are visible along the banks of the road near Tolstoi, Manitoba. Plowing largely restricts their spread into adjacent fields. (R. E. Wrigley)

specimens prior to 14 April, and obviously males were ready to breed at an earlier date. Seven adult males were taken from 22 June to 20 October showed a decrease in testes length (5 to 10 mm). Vaughan (1962) determined that testes 11 to 12.5 mm and larger were producing sperm.

Sudman et al. (1986) have reported the gestation period to be 51 days. In the present study (Table 1) 25 females were in estrus (from 14 April to 25 July), including 21 from April, one on 25 May, and one on 1 June, and possibly 2 in July. Twenty females were pregnant from 22 April to 25 July and averaged 3.9 embyros (range 3 to 6). The lengths of embryos examined from females on 22 April measured 8 mm and 25 mm respectively, so that mating may have occurred in late March. Placental scars were found in 20 females from 1 June to 9 October (old scars), and averaged 4 per litter (2 to 8). Twenty adult females exhibited no sign of having borne a litter, as follows: March 1, April 4, May 1, June 12, July 2. Vaughan (1962) found that in Colorado, litters averaged 3.4 with a range of 1 to 8, and that placental scars remained visible for up to three months.

With these results we anticipated that births in the Manitoba population would be restricted to the period from mid-April to late July. The onset of the breeding season was difficult to research because pocket gophers were inaccessible during this time snow covers the ground in March and the ground is usually frozen in early April. Much to our surprise, we received from a farmer a young Plains Pocket Gopher which had been floundering in the snow on 5 March. It weighed only 111 g and blood on the tail indicated it had been driven out of its maternal burrow. Vaughan (1962) found that females forced their young from the burrow (mostly in June), when the latter weighed between 80 and 100 g. These offspring frequently exhibited numerous cuts on the tail. Sudman et al. (1986) also estimated that young dispersed from the maternal burrow at about 49 days of age, when they weighed 80 100 g. Adult weight and total length were achieved at 100 days. The small size of this Manitoba specimen (adults weigh 190 to 432 g) and the tail injury suggest the possibility that its mother commenced breeding as early as January or February, as occurs in the southern half

TABLE 1. Reproductive data on the Plains Pocket Gopher in southcentral Manitoba.

Date	Estrous Females	Number and Length of Embryos (mm)	Number of Placental Scars
14 April	11		
22	3	3– 8	
		4– 8	
		4–25	
27	2	4– 8	
28	5	5–15	
25 May	1	6–	
1 June	1	5– 5	4
		5– 9	
		4– 3	
		3– 7	
9			4
12			3
17		4–11	3,3
19		3–13	4
		4–38	
22			3
24		4–24	
		4–13	5,2,4
25		3–24	4,4,3
26		3–34	3,3
		3–11	
		4–23	
25 July	2	3– 6	
26			7,5
9 October			8,3, -old scars
Average		3.9 (n = 20)	4.0 (n = 19)
Range		3– 6	2– 8

of the range (Vaughan 1962). An alternate possibility is that the animal was born late the previous summer and experienced retarded growth over the winter. Numerous young, weighing from 78 to 116 g, were captured from 17 June to 26 July in our sample.

The uteri of two adult females taken on 25 July were slightly swollen, as if in the early stages of estrus, and there was no indication of earlier breeding. Other studies (Vaughan 1962) have found that a small percentage of individuals become pregnant in July and August. With our limited data, it appears that litters may be born from late January to August, but most are restricted to the period from late April to early July. Such an extended breeding season has adaptive value considering that pocket gophers have low opportunity to meet the opposite sex because of their subterranean existence and often isolated home ranges. During the first part of the breeding season in Manitoba, the frozen ground and snow cover would restrict accessibility of mates to those that live in adjacent burrow systems, for long-range surface movements are unfeasible. (Some limited activity does occur on the ground surface under the snow in early winter, as is evident by cores of excess earth stored in snow tunnels.) As Vaughan (1962) pointed out, there is considerable evidence that movements of pocket gophers from one burrow to another during the height of the breeding season are accomplished primarily underground, especially when the soil is frozen. Added to this dilemma of mating access is the uneven sex ratio often reported in this species (Mumford and Whitaker 1982), which we found at the unusually high ratio of 77 per cent in favour of females. One-third of adult females were barren in our study, although a few of these might have become pregnant before the end of the breeding season. Considering that the average lifespan is only about two years, and the maximum five years (Jones et al. 1983), a high proportion of pocket gophers, especially those individuals that disperse some distance from the main colony, never have the opportunity to breed.

OLIVE-BACKED POCKET MOUSE, *Perognathus fasciatus*

This tiny rodent is one of the rarest and least-known Canadian mammals (Figure 3). Prior to our study there were only about one dozen specimens known from Manitoba, mostly collected between the years 1913 and 1926 by local naturalist Stuart Criddle (1929) at Aweme (north of Treesbank) near the Carberry Sandhills. Soper (1946) added records at Oak Lake and the junction of the Souris and Antler rivers. We searched far and wide for this species, directing our collecting activities to regions of sand and sandy-loam deposits originating from basins and deltas of former glacial lakes Agassiz and Souris (Wrigley 1974). Our first successful capture (by hand) was on 22 October 1970 in the Carberry Sandhills, in a blowout with pioneer forbs and grasses within spruce-aspen-oak savanna. Several years later we succeeded in collecting 17 mice in one night in a

FIGURE 3. Olive-backed Pocket Mouse from Virden, Manitoba. (R. R. Taylor and R. E. Wrigley).

road-side weedy area nearby. Since then we have amassed a series of 144 specimens, a number of which were kept alive several years for observation. Several of these mice were brought in by biologist-farmers who had turned them out of their burrows while cultivating fields.

This species (a hibernator) was found to be most abundant in sandy fields east of Virden. On 1 October 1980 we began walking along the rows of rye stubble at 19:30 while it was still light enough to see without a lantern. The night did not look too promising for it was 7° C, raining periodically, and the wind was blowing so hard that gusts almost blew us off balance. Yet we caught 20 pocket mice and missed another by 21:45, after which the mice appeared to cease their above-ground foraging. The cheek pouches of almost every mouse were packed full of seeds. An additional 11 specimens were gathered the following evening. Tracks, short and blind excavations, and dust-bath depressions were seen at a number of sites in the sandy soil.

Few pocket mice were found in native fields of mesic or xeric mixed-grass prairie. In such habitats, the mice were attracted to disturbed sites such as weedy roadsides, trails, pasture, dunes, and quarries. Most of our specimens were obtained from the edge of, or inside, crop fields, such as rye, wheat, oats, barley, flax, sunflowers, alfalfa, and hay. Plenty of weedy plants were usually present, providing a rich source of seeds. In fact, the Weedy Peppergrass (*Lepidium densiflorum*) was almost always noted in pocket mouse habitat. Seeds of Black Bindweed (*Polygonum convolvulus*), Bugseed (*Corispermum nitridum*), and Russian Thistle (*Salsola kali*) were frequently noted in the mice's cheek pouches.

In spite of a significant number of Olive-backed Pocket Mice now available for study, the species is still known from only about 17 localities within six areas (many close together), revealing its highly localized distribution and specific habitat requirements — sparse weedy growth on well-drained sandy soil. It is quite possible that the pocket mouse has benefited from the advent of agriculture, which provides a steady source of food from grain and weed plants, as well as a more open ground cover resulting from the removal of the prairie sod. New distributional records are in the vicinities of Glenboro, Cypress Hills, Oak Lake, Pierson, Lyleton, and Virden. Range extensions are here reported at 8 km S, 6.3 km W Pierson (25 km farther west); 4 km N, 2.4 km E Virden (26 km to the northwest); and 8.8 km S, 3.5 km E Cypress River (30 km to the southeast).

As pointed out by Jones et al. (1983) and Banfield (1974), there has been no thorough study of reproduction in the Olive-backed Pocket Mouse; no doubt this lack is related to the species' rarity over much of its range. Criddle (1915) was convinced that only one annual litter was produced, even though only one pregnant female, containing four embryos in the middle of May, was available at that time in Manitoba. Bailey (1926) noted six embryos in a female captured on May 13 and he thought that females had only one litter in a year in North Dakota. In Saskatchewan, Nero (1958) reported three pregnant females that were taken on 11 July and he suspected that two litters were possible. Turner and Bowles (1967) noted that five females collected in the latter half of June in North Dakota were pregnant. Lampe et al. (1974) found that three Montana females contained embryos as well as placental scars in mid-July, and another in late July revealed 11 placental scars of two ages. Pefaur and Hoffmann (1974) summarized breeding data from museum collections and the literature and reported an average of 5.4 (2 to 9) embryos and 5.6 (2 to 12) placental scar counts in 35 females collected in North Dakota, Montana, and Saskatchewan. They presumed that the placental scar count of 12 represented two litters. Males were in breeding condition (testes length greater than 6 mm) from April to July and pregnant females were found from mid-May to mid-August (5 August was the latest record). These authors also believed that two litters were produced annually, with a rest period in June.

Table 2 outlines our reproductive data for the Olive-backed Pocket Mouse, which substantiate the presence of at least two litters per year. The series of specimens covered the period from 10 May to 23 October (hibernation dates are

TABLE 2. Reproductive data on the Olive-backed Pocket Mouse in southwestern Manitoba.

Date	Estrous Females	Number and Length of Embryos (mm)	Number of Placental Scars
6 July	1	5–18	5,5
28			4
29		5–10	3,6,7,8,8
9 August		10– 6	3,11
12		4– 4	
		5– 8	6
		6–14	
		7–10	
		7–15	
13 August			7
14 September			6
15			4
Average		6.1 (n = 8)	6.0 (n = 14)
Range		4–10	3–11

unknown), which unfortunately missed the onset of the first breeding period in April and early May. Numerous 6 g young were collected on 6 and 7 June, obviously born during May and just appearing out of the nest burrows. Only eight pregnant females were found in July and August, with an average of 6.1 embryos per litter and a range of 4 to 10. From July to September, 14 females averaged 6.0 placental scars with a range of 3 to 11. Three specimens from 1 and 2 October showed 1, 2, and 3 placental scars, but these were old and could not be counted with any assurance. Males with a testes length of 6 to 7 mm were noted from 10 May to 2 October. In summary for Manitoba, it appears that the breeding season begins in late April, and with a gestation lasting nearly four weeks, the first litters are born in late May and the young appear above ground in early June. A second breeding peak is evident from early July to mid-August, including both females breeding for the first time as well as those having their second litter of the year. The discovery of a female containing 10 embryos is surprising, considering the small size of the species (ranging from 10 to 14 g). The presence of 11 placental scars in this and other studies might actually represent one large litter rather than two as formerly believed.

We suspect the Olive-backed Pocket Mouse remains in its underground quarters (undergoing alternating bouts of torpor and periodic arousals) from November to early April, thereby avoiding the inhospitable conditions of winter in this area. In many years the fields are blown clear of snow, which combined with intense cold (down to –45° C) likely cause many of the mice to freeze in burrows which are less than 1 m deep. The activity pattern of torpor, arousal, and feeding on stored seeds has not yet been investigated.

PRAIRIE VOLE, *Microtus ochrogaster*

In listing the mammals of Manitoba, Seton (Thompson 1886) suggested the possible occurrence of the Prairie Vole, and in fact, his field notes of 1884 (Seton 1909) described this species as common but sporadic from year to year. Criddle (1926) accumulated notes on their habits at Aweme (Treesbank) and prepared about 29 specimens from 1925 to 1951. Criddle (1929) noted that the species was very common in specific upland habitats. Green (1932), in a paper on the mammals of Riding Mountain National Park, stated that the "Least Meadow Vole (*Microtus minor*)" [using now-abandoned common and scientific names of the Prairie Vole] was fairly numerous, but failed to mention the presence of the Meadow Vole (*Microtus pennsylvanicus*) – in reality the most abundant mammal in the Park. No specimens of the Prairie Vole seem to have been saved. Undoubtedly, Green confused the names or specimens of the two voles, and there is no evidence that the species occurs this far north, in spite of our intensive search for it. This erroneous record has often been shown on distribution maps (e.g., Hall 1981) up to the present time.

Soper (1961) collected in the province from 1927 to 1948 and listed 32 specimens from five localities in southwestern Manitoba, indicating that the Prairie Vole was "capriciously distributed and apparently more often scarce." During the present study we succeeded in capturing 136 specimens from 12 localities, so that a clearer picture can now be drawn of the species' distribution. In Manitoba it is most often found in the sandy, arid grassland of the extreme southwest and becomes increasingly rare and isolated to the north and east. The following localities represent disjunct populations separated by great distances from the main body of the range – Fort Whyte (south side of Winnipeg), Ridgeville, St. Claude, Chatfield, and St. Lazare. The former two populations were reported by Soper (1961) and we believe they have been extirpated by housing developments and agriculture. The Chatfield and St. Lazare specimens extend the known range north by 112 km east and 90 km northwest, respectively.

By far the most productive plant community for Prairie Voles was xeric mixed-grass prairie, where 70 specimens were procured. Next were various dry, disturbed and pioneer communities (24 specimens) such as grass-weed fencerows and edges of fields of barley, wheat, and sunflowers; sand dunes with sparse ground cover; and heavily grazed pasture. Twenty-one were found in oak-aspen-savanna (occasionally with White Spruce present), 13 in mesic mixed-grass prairie, and 8 in shrubs of rose (*Rosa* sp.), hazel (*Corylus americana*), snowberry (*Symphoricarpos albus*), and silverberry (*Elaeagnus commutata*).

This species appeared on four 2-ha quadrats – 7 individuals in xeric and 11 in mesic mixed-grass prairie (Figure 4), 2 in xeric shurbs, and 5 in xeric savanna. Prairie Voles are known to be active during the day as well as the night, and among our records were a male and female caught simultaneously in the same mouse (snap) trap at 15:00 on a hot (30° C), sunny day. As an indication of the Prairie Vole's co-inhabitants and their relative numbers, the following mammalian species were caught in one extraordinary night of trapping on 22 October 1970 in the Carberry Sandhills: 82 Deer Mice (*Peromyscus maniculatus*), 48 Southern Red-backed Voles (*Clethrionomys gapperi*), 27 Prairie Voles, 26 Meadow Voles, 9 Masked Shrews (*Sorex cinereus*), 5 Least Chipmunks (*Eutamias minimus*), 3 Red Squirrels (*Tamiasciurus hudsonicus*), 1 Northern Grasshopper Mouse, 1

FIGURE 4. A 2-ha quadrat in this mesic mixed-grass prairie (*Andropogon-Stipa-Bouteloua*) near Margaret, Manitoba produced 11 Prairie Voles and 7 other species (125 specimens) of small mammals. (R. E. Wrigley).

Olive-backed Pocket Mouse, and 1 Northern Pocket Gopher (altogether 203 specimens of 10 species).

We could locate only scattered references on reproduction in this region. Criddle (1926) found young in a nest on 2 May and as late as 30 September, with litter size ranging from 1 to 8. Soper (1946) reported three juveniles (8.1 to 9.2 g) on 16 May, and Seton (1909) saw young in a nest on 23 October. Jones et al. (1983) mentioned a gestation period of three weeks and litters averaging 3 or 4 young (range of 1–7) on the Great Plains.

Our results (Table 3) showed only five pregnancies from 23 May to 13 August, averaging 5.8 (5–7) young. Placental scars were observed in 15 females from 2 June to 23 October, with a mean of 7.2 scars (observed range 6–10). These may have included several females with scars from two litters; however, the average litter size does appear to be larger in Manitoba than in populations to the south. We suspect the Prairie Vole produces two or more litters a year in Manitoba, with females becoming receptive at one month of age as occurs in the northern Great Plains (Jones et al. 1983).

NORTHERN GRASSHOPPER MOUSE, *Onychomys leucogaster*

Prior to the present study there were fewer than 12 specimens of the Northern Grasshopper Mouse (Figure 5) known from Manitoba, half of these collected by Seton (1909) and Criddle (1929) in the Carberry Sandhills. Other localities noted from museum specimens were Ninette, Melita, and Boissevain. The southern boundary of Riding Mountain National Park has been considered to be the northern record where Green (1932) reported capturing several of the mice, but no specimens are known to confirm this. We were unsuccessful in finding the mouse in this region. Wrigley (1974)

TABLE 3. Reproductive data on the Prairie Vole in southwestern Manitoba.

Date	Estrous Females	Number and Length of Embryos (mm)	Number of Placental Scars
23 May		6–21	
		6–35	
2 June			6
4			6,6
3 July		5–17	
7		5–7	
8 August			6
9			7
11			6
12			8
13		7–3	7
22			6
23			9
13 September	1		
15			8,10, -old scars
16			9
23 October			-old scars
Average		5.8 (n = 5)	7.2 (n = 13)
Range		5–7	6–10

FIGURE 5. Trapped Northern Grasshopper Mouse (above) and Deer Mouse, illustrating the stockier build and shorter tail of the former. While the two species' food habits overlap, the Grasshopper Mouse concentrates on insect prey, while the Deer Mouse eats a higher proportion of seeds. (R. E. Wrigley).

reported only six additional specimens taken in the Carberry Sandhills and near Oak Lake, although concentrated trapping in apparently suitable habitat at over 100 sites had been carried out throughout southwestern Manitoba.

We have now secured 96 specimens, adding the localities of Lauder, Lyleton, Pierson, Virden, Neepawa, and Cypress River – all range extensions of 30 to 55 km. A small area near Virden (Figure 6) produced most of these mice, and was the only site where Grasshopper Mice could be described as common. Numerous exposed burrows (some appearing to be renovated holes of Thirteen-lined Ground Squirrels, *Spermophilus tridecemlineatus*), were observed and provided sites of easy capture. This species was partial to dry, light soils with a high proportion of bare ground. It was taken along the grassy edges or within over-grazed pastures and fields of rye, oats, barley, wheat, sunflowers, alfalfa, and hay. Dense grass or undisturbed areas were avoided. In this regard it resembled the habitat preferences of the Olive-backed Pocket Mouse. The following species (and numbers) were collected in association with Grasshopper Mice in seven nights (6–10 August, 1–2 October, 1980) of collecting in the Virden area: 373 Deer Mice, 58 Meadow Voles, 48 Olive-backed Pocket Mice, 44 Northern Grasshopper Mice, 43 Southern Red-backed Voles, 31 Masked Shrews, 8 Northern Pocket Gophers, 6 Short-tailed Shrews (*Blarina brevicauda*), 5 Least Chipmunks, 3 Richardson's Ground Squirrels (*Spermophilus richardsonii*), 3 House Mice (*Mus musculus*), 2 Thirteen-lined Ground Squirrels, 1 Franklin's Ground Squirrel (*Spermophilus franklinii*), 1 Red Squirrel, 1 Meadow Jumping Mouse (*Zapus hudsonius*), and 1 Western Jumping Mouse (628 specimens of 16 species).

FIGURE 6. Overgrazed pasture near Virden, Manitoba – optimal habitat of the Northern Grasshopper Mouse and Olive-backed Pocket Mouse. Six species of small mammals were caught in this pasture and ungrazed border on the right. (R. E. Wrigley).

TABLE 4. Reproductive data on the Northern Grasshopper Mouse in southwestern Manitoba.

Date	Number and Length of Embryos (mm)	Number of Placental Scars
18 April	4-	
8 June	4- 5	
	5- 7	
17	3-10	
29 July		6
11 August		4
12		4
13	3- 8	
	5- 7	
	2-13	
14	5- 4	
	4-14	
	5-18	
Average	4 (n = 10)	4.7 (n = 3)
Range	2-5	4-6

Remarkably little is known about the reproductive biology of the Northern Grasshopper Mouse (Banfield 1974). The gestation period has been found to be as short as 26 days and up to 47 days if the female was lactating. Over much of the range mean litter size was reported to be 4 (1-6), with several litters produced from April to early October (Smith et al. 1975). Both sexes have been found to be capable of breeding at four months of age in captivity, but wild mice did not appear to become sexually active until their second year (Jones et al. 1983). Soper (1964) noted two litters of 2 to 5 young per year in Alberta. In the present study (Table 4) ten litters averaged 4.0 (2-5) embryos and 4.7 placental scars (4-6), with pregnancies from 18 April to 14 August. Juveniles were caught throughout June, July, and August (indicating at least two annual litters) and none was in breeding condition.

WESTERN JUMPING MOUSE *Zapus princeps*

The Western Jumping Mouse (Figure 7) was undetected by Seton (1909) in Manitoba and was first recorded by Criddle (1929) at Aweme (north of Treesbank) where it was listed as rare. To Criddle's series of 17 specimens (collected from 1912 to 1936) at Aweme and one other from Souris, were added four specimens from Pembina River (north of Mowbray) and Pelican Lake by Soper (1961). The National Museum of Natural Sciences (now Canadian Museum of Nature) has six from Shoal Lake (the northern record for the province) and two from Oak Lake. During the present study we captured 105 specimens at 28 localities, extending the range marginally to 1 km N Cromer; 4 km S, 4 km E Virden; 1.8 km S, 6.4 km E Neepawa; 6.4 km S, 18.2 km W Morden; and 8 km W St. Claude – a further 83 km east of Criddle's Aweme record. Unexpectedly, three Western Jumping Mice were turned in (by two mammalogy students of W. Pruitt, Jr., University of Manitoba) from area on the northwest periphery of Winnipeg – a range extension of 93 km east of our St. Claude record. These two eastern peripheral populations appear to be isolated from the main range to the west.

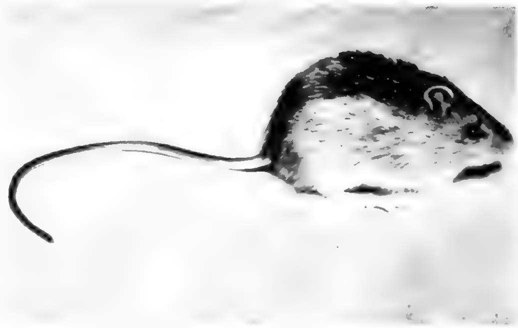

FIGURE 7. Western Jumping Mouse (R. E. Wrigley).

Western Jumping Mice were frequently caught in the same vicinity as Meadow Jumping Mice but it required a keen eye to differentiate the two rodents. Habitat selection of these species overlapped completely, but we noticed an inverse relationship in abundance along a moisture gradient – the Western Jumping Mouse preferring drier conditions. An astonishingly high population was found at the University of Brandon Field Station on the east shore of Oak Lake from 14 to 17 June 1979. As we walked through the tall growth of Brome Grass (*Bromus* sp.) while unloading our gear, several jumping mice were seen bounding away, one ricocheting off the building wall. Within a few days, we collected 50 Western and 10 Meadow Jumping Mice in traps set through the grass, shrubs, and along the edge of deciduous forest. Considering the former species' general scarcity in Manitoba (usually only one or two individuals were caught in several nights of trapping), this abundance of adults in an 0.5-ha area was exceptional. Also unexpected was the high activity of the mice on hot (37°C), windy, sunny days, since they are generally mostly active at night and less so on cloudy days.

On rich loam terraces of the Souris River north of Margaret, 2-ha quadrats produced eight specimens in dry shrubs of Silverberry, Snowberry, Choke Cherry (*Prunus virginiana*) and raspberry (*Rubus idaeus*); and two specimens in mixed-grass prairie of Little Bluestem (*Andropogon scoparius*), Needle Grass (*Stipa comata*), June Grass (*Koeleria gracilis*), and Blue

TABLE 5. Reproductive data on the Western Jumping Mouse in southwestern Manitoba.

Date	Estrous Females	Number and length of Embryos (mm)	Number of Placental Scars
12 May	1		
13 June		4- 6	
14		4- 5	
		5- 6	
15		*7- 2	*present
		7-10	present
		8- 8	
		6-11	
		6-19	
16		7- 7	
		6-11	
		4-11	
		6- 9	
17		5-14	5
		6-12	
		6- 4	
20		6-16	
		6 + 1 reabsorbed	
11 Aug		8- 2	
Average		5.9 (n = 18)	5 (n = 1)
Range		4- 8	

*same female

Grama (*Bouteloua gracilis*). Western Jumping Mice were also found in shrubby growth along the edges of forests such as aspen, oak, and maple-ash; in oak savanna; shrub patches surrounded by dry prairie; disturbed sites of weeds and grass; and occasionally in damp sedge-grass borders of watercourses. Lastly, one dozen specimens were secured from the dry, grassy borders of grain fields (oats, wheat, rye) and alfalfa.

Our sample of Western Jumping Mice covered the period from 12 May to 10 October (a fat juvenile). Limited data suggest that most individuals emerged from hibernation in May and retired in September, with only juveniles active into October. Males revealed enlarged testes (6 to 8 mm length) from 18 May to 23 August. Table 5 contains reproductive data gleaned from 22 females – 1 was in estrus in May, 3 revealed placental scars, and 18 were pregnant between 13 June and 11 August, averaging 5.9 young and a range of 4 to 8. The large 30-g female taken on 15 June showed both embryos and possible placental scars, evidence of a second litter, although both Banfield (1974) and Jones et al. (1983) stated that this species produces, as a rule, one litter a year, between mid-June and late July. Unfortunately, we lacked specimens from July, but a female (apparently born in the spring) taken on 11 August was pregnant. Since the Meadow Jumping Mouse is known to have two or three annual litters, and male Western Jumping Mice have enlarged testes from emergence to well into August, we believe it is probable that many individuals of the western species also produce a second litter in summer. However, our data on females do not shed much light on this question. Litter size for Manitoba specimens was similar to that reported by the above-mentioned authors. Juveniles (9 to 14 g) were noted on 10, 14 August, 4, 6, 10, and 14 September, indicative of the frequency of late pregnancies in July and August.

The sex ratio was 68 percent males, 32 percent females (n = 123), which is a considerably higher ratio than Wrigley (1972) reported for the Woodland Jumping Mouse, *Napaeozapus insignis* (55: 45), and Quimby (1951) and Whitaker (1963) for the Meadow Jumping Mouse (48: 52; 53: 47, respectively). Perhaps males were caught more frequently in our study due to their greater activity compared to pregnant females, and the generally larger home ranges of male jumping mice (Wrigley 1972).

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Insect Visitors to the Guelder Rose, *Viburnum opulus* var. *opulus* (Caprifoliaceae), in London, Ontario

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Kranntiz, Pam G., and M. A. Maun. 1991. Insect visitors to the Guelder Rose, *Viburnum opulus* var. *opulus* (Caprifoliaceae), in London, Ontario. Canadian Field-Naturalist 105(1): 13–17.

Insects were observed at and collected from inflorescences of Guelder Rose, *Viburnum opulus* var. *opulus* L., in an effort to determine the effectiveness of the pollination behavior of different insects. Abundance, relative size of pollen loads, length of visit, and proportion of pollen load belonging to *V. opulus* var. *opulus* were recorded. Forty-nine species of insects were collected, ranging across five orders. Hoverflies (Syrphidae) and native solitary bees (Halictidae and Andrenidae) were the families most represented. Pollen samples taken from most of these insects contained a majority of pollen grains from *V. opulus* var. *opulus* (80%). Tarnished Plant Bugs moved infrequently between plants, and therefore did not pollinate many plants. Non-syrphid flies and beetles carried minimal amounts of pollen. Large syrphid flies each carried approximately 300 grains of pollen, but were not very abundant whereas solitary bees were abundant, had large pollen loads (far exceeding 300 grains), and moved frequently between plants (mean visit length = 54.4 s). They were therefore the most effective of the insect visitors in pollinating *V. opulus* var. *opulus*.

Key Words: Guelder Rose, *Viburnum opulus* var. *opulus*, pollination, pollinator effectiveness.

The evolution of mutualistic interactions such as that between flowering plants and pollinators has seldom resulted in specific one-to-one species relationships (Howe 1984). The coevolution of tight mutualistic relationships is dependent on the frequency of occurrence and the fitness consequences of the interaction (Schemske 1984). Floral complexity limits the variety of pollinators and therefore increases the effectiveness of successful pollinators (Schemske and Horvitz 1984). Simple, open flowers are "promiscuous"; they are visited indiscriminantly by many different insects (Grant 1949), and tend to produce more pollen per ovule than complicated flowers (Lindsey and Bell 1984), perhaps due to the inefficiency of pollen transfer. Even though these flowers do not exclude pollinators the majority of successful pollinations can be attributed to only a few pollinators (Lindsey 1984). As such, evolution of a more limited pollination relationship may be possible, even in simple-flowered plants.

The shrub *Viburnum opulus* var. *opulus* L. has simple, open flowers with limited nectar rewards. This present study was carried out to 1) determine whether *V. opulus* var. *opulus* attracts a wide variety of insects, and 2) assess the ability of different insects to effect pollination. It was predicted that even with a "promiscuous" pollination system, *V. opulus* var. *opulus* would be successfully fertilized by only a few of the insect visitors.

Study organism and site

Viburnum opulus var. *opulus* (Guelder Rose), is a tall shrub (3–4 m) introduced originally to North America from Europe as an ornamental shrub. It has become naturalized in southern Ontario and in parts of the United States. The closely related native species, *V. opulus* var. *americanum* Aid., (also known as *Viburnum trilobum* Marsh) is widely distributed throughout southern Canada and the northern United States (Gleason and Cronquist 1963).

Both species require insect visitation for maximum fertilization (Krannitz and Maun 1991). The flowers are arranged in umbel-like corymbs and have shallow (2–3 mm) and wide (4 mm) corolla tubes (Donoghue 1980). Six species of *Viburnum*, including both varieties of *V. opulus* have large (30 mm across), showy, sterile flowers which surround the fertile flowers in a ring in each inflorescence (Donoghue 1985). From four of these species, including *V. opulus*, completely sterile forms have been developed. The sterile flowers do not produce nectar or pollen.

The study site was located at the former Plant Sciences Field Station of the University of Western Ontario in London, Ontario (42°59′N, 81° 15′W) where shrubs of *V. opulus* var. *opulus* were planted in a large pasture.

Methods

Insects were collected at peak flowering time (1–9 June) from *V. opulus* var. *opulus* at the Plant Sciences Field Station. They were collected from plants in full bloom (during the day) and killed with ethyl acetate. Collections were made from plants other than the ones being observed for insect visitation. The insects were identified by a number

TABLE 1. The number of different insect species collected from flowers of *Viburnum opulus* between 1-9 June 1985 at the Plant Sciences Field Station, London, Ontario.

Order	Family	Species	Number
COLEOPTERA	Elateridae	**Ampedus aerolatus*	1
	Dermestidae	*Anthrenus fuscus*	1
		A. verbasci	1
	Mordellidae	*Mordella* sp.	1
	Nitulidae	*Carpophilus brachypterus*	1
	Cantharidae	*Cantharis* sp.	1
	Scarabaeidae	*Trichiotinus assimilis*	1
	Cerambycidae	*Molorchus bimaculatus*	1
		Cyrtophorus verrucosus	1
HEMIPTERA	Miridae	*Lygus lineolaris*	15
		Corimelaena pulicaria	1
LEPIDOPTERA	Arctidae	*Cisseps fulvicollis*	2
	Hesperidae	*Polites themistocles*	1
DIPTERA	Dolichopidae	*Condylostylus* sp.	1
	Calliphoridae	*Pollenia rudis*	5
	Tachinidae	*Platymya confusionis*	1
		Hyalomyodes triangulifer	1
	Rhagiomidae	**Chrysopilus proximus*	1
	Syrphidae	*Syritta pipiens*	1
		Orthoneura pulchella	1
		Chrysogaster antitheus	4
		Toxomerus marginatus	17
		T. geminatus	1
		Eristalis arbustorum	3
		**E. dimidiata*	1
		Temnostoma alternans	1
		T. acrum	1
		Syrphus rectus	2
		Didea fuscipes	1
	Muscidae	*Coenosia tigrina*	2
	Bibionidae	*Dilophus* sp.	5
	Chloropidae	?	1
	Anthomyiidae	*Delia platura*	22
		D. florilega	3
	Culicidae	*Aedes stimulans*	1
HYMENOPTERA	Formicinae	*Formica fusca*	1
		Prenolepsis imparis	1
	Halictidae	*Lassioglossum zonulum*	2
		L. coriaceum	1
		Augochlorella striata	1
		Dialyctus sp.	3
	Andrenidae	*Andrena cressoni*	3
		A. imitatrix	3
		A. nasonii	3
		A. vicina	3
		A. miranda	2
		A. nr. *wilkella*	1
		A. commoda	2
	Tenthredinidae	*Hoplocampa sialica*	1
	Pteromalidae	*Pirene penetrans*	2

*These insects were collected from the sterile form.

of entomologistsat several institutions (see Acknowledgments). The andrenids in the collection were deposited at the Illinois Natural History Survey. The rest of the collection has been deposited either at the Canadian National Collection in Ottawa, or at the University of Guelph.

Pollinator visitation to inflorescences was observed for a total of 27.5 diurnal hours over 6 days (1–7 June, excluding 5 June). Two or three inflorescences were observed at one time, and the periods were of either 15 or 10 minutes duration. The pollinators were identified on sight at least to

the rank of order. Data was collected on the type of insects visiting the inflorescences, time spent by each insect and the behavior of the insect on the inflorescence.

Ideally, the effectiveness of different insects in pollination would be determined directly by measuring the success at fertilization following the visit of each insect. Plants with open pollination systems like *V. opulus* var. *opulus* are visited by many different insects, making this procedure logistically very different. Additionally, the frequency of visitation is low (Krannitz, personal observation) making observations of all species time-consuming and virtually impossible. Therefore, pollinator effectiveness was determined indirectly by measuring abundance (number of individuals collected and observed visiting the inflorescences), length of visits, relative size of pollen loads, and floral constancy (percentage of pollen on insect body belonging to *V. opulus* var. *opulus*). These variables have been shown to be good estimators of pollinator effectiveness (Lindsey 1984).

The constancy of a pollinator visiting flowers of *V. opulus* var. *opulus* was determined by taking pollen samples from most (those damaged were not sampled) collected pollinators, and mounting them on slides in Beattie Jelly (Beattie 1971). Pollen was collected from other species of plants flowering at the time to facilitate the identification of foreign pollen on the slides. For slides with more than 300 pollen grains, one field of view (at 400× magnification) was randomly selected and split into four sections for ease of counting. Approximately 300 pollen grains were within that field of view. All pollen grains were accounted for on slides with approximately 300 or fewer grains. The pollen was identified, at least to the rank of genus and usually species. Samples with fewer than 200 pollen grains were generally not included. The proportion of pollen of each plant species in a sample was calculated and then arcsine square-root transformed before calculating means and standard errors. The data presented were back-transformed.

The amount of pollen carried by a solitary bee far exceeded what could be placed on a slide. Therefore, all pollen grains carried by a bee were not counted. The number of pollen grains on the other insects was estimated by counting the number of pollen grains that we were able to remove from the insect body and place on the slide. Because this was not an accurate pollen count of all grains, pollen load was estimated on a relative scale.

Results

Five orders, 25 families and 49 species of insects were collected from the flowers of *V. opulus* var. *opulus* (Table 1). Hoverflies (Syrphidae) and native solitary bees (Andrenidae and Halictidae) were the most represented families. Two pests of agricultural crops in southwestern Ontario were common visitors: *Lygus lineolaris* (Tarnished Plant Bug), and *Delia platura* (Seed-corn Maggot) (Table 1). Other agricultural pests such as *Coenosia tigrina* and *Delia florilega*, were also collected, but less frequently.

Solitary bees spent the least amount of time on each inflorescence during a foraging bout, while *Lygus lineolaris* spent the most time (Table 2). In fact, the average time recorded for *Lygus lineolaris* was an underestimation of visiting time, since the observation period usually began with the insect present, or ended before its departure. The majority of visits were from *Delia* spp. (Table 2). The next most frequent visitors were syrphid flies (predominantly *Toxomerus marginatus*).

Solitary bees, including the smallest species, carried the greatest amount of pollen ($\gg 300$ grains) which was located on their heads, thoraces and pollen baskets. The large syrphid flies (*Temnostoma* spp., *Eristalis* spp., *Syrphus rectus*) and the hemipteran *Lygus lineolaris* carried the second largest amount of pollen (approximately 300 grains). The least amount of pollen was carried by the syrphid *Toxomerus marginatus*, the anthomyiid *Delia* spp., and the beetles (< 300 grains).

At least 75 percent of the pollen carried by all insect groups belonged to *V. opulus* (Table 3), with

TABLE 2. Mean number of seconds and standard error spent by different insects on an inflorescence of *Viburnum opulus*. Means followed by different letters are significantly different at $P < 0.05$ (Turkey's studentized range test).

Insect	Time (seconds)	S.E.	n
Lygus lineolaris	222.9 a	67.69	7
Pteromalidae	124.6 ab	19.25	13
Delia spp.	106.7 b	16.09	70
Syrphidae (mostly *Toxomerus marginatus*)	98.2 b	17.29	32
Andrenidae and Halictidae	54.4 b	13.00	11

no significant difference between them (F = 1.35, P = 0.26). The most abundant insect visitor, *Delia platura*, had 94.8% (± 0.22 S.E., n = 10) of its pollen sample belonging to *Viburnum opulus*, with little variation. However, the second most abundant insect visitor, *Toxomerus marginatus*, had the smallest proportion of *V. opulus* pollen, and it was the most variable of the insect visitors (55.7%, ± 13.55, n = 5). Pollen samples from the common *Lygus lineolaris* had a high proportion of grains from *V. opulus* (Table 3). Bees visited many different plants, but still had a high proportion of pollen from *V. opulus*.

No pollen samples were taken from the minute but abundant chalcid wasp (family Pteromalidae). Under the dissecting scope, only a few grains of pollen were seen on the 1.5 mm long body of this insect.

Discussion

The great diversity of insect visitors to *V. opulus* made an indirect rather than a direct assessment of pollinator effectiveness necessary. The two native bee families Halictidae and Andrenidae were found to be the most effective pollinators; they were abundant, they moved actively among plants, remaining the shortest period of time at each plant, and carried the greatest quantities of pollen. These results agree well with Lindsey (1984) who showed these two families to be the most effective pollinators for the "promiscuous" species she worked with. That halictids and andrenids did not have the highest proportion of *V. opulus* var. *opulus* pollen on their bodies is understandable, when one considers that some of the other insects did not move very frequently to other plants, but stayed at a particular inflorescence for a long time. This was especially true for *Lygus lineolaris*. Hatfield et al. (1983) present similar data on the duration of visits by this species to flowers of cotton, alfalfa and mustard.

Native solitary bees move frequently between plants because they actively collect pollen (Faegri and van der Pijl 1979). By contrast, syrphid flies visit flowers primarily to consume pollen and nectar (Gilbert 1985a). Male syrphid flies use floral sites primarily for mating with females (Gilbert 1985b) who consume pollen for ovarian development (Waldbauer 1983). This may explain the small pollen loads carried by the abundant small syrphid *Toxomerus marginatus*. The larger syrphid flies carried large amounts of pollen, but in this study they were not very abundant. In Lindsey (1984), only one out of ten species of "important" pollinators was a syrphid, and it was important in only one of nine populations. In a study on the visitors to apple blossoms, the same genera of large syrphids as in this study were also not abundant

TABLE 3. Mean percent pollen type in samples of approximately 300 pollen grains. Data were arcsine square-root transformed to calculate the means.

	Insect Group					
	Coleop.	Hemiptera *Lygus lineolaris*	Lepidoptera *Cisseps fulvicollis*	Diptera	Diptera Syrphidae	Hymenoptera Halictidae Andrenidae
n	3	10	1	13	14	20
Plant species						
Viburnum opulus Guelder Rose	93.7	95.8	91.3	93.3	79.4	88.3
Hesperis matronalis, Dame's Rocket	0.15	0.2	5.3	0.026	1.77	1.88
Chrysanthemum leucanthemum Ox-eye Daisy	1.85	1.0	1.2	0.61	2.32	0.57
Erigeron spp. Fleabane		0.2		0.0095	0.23	0.74
Medicago lupulina Black Medick	0.37	0.03	1.2	0.38	0.15	0.42
Ranunculus sp. Buttercup	2.83	0.8	1.0	0.04	3.79	0.14
Taraxacum officinale Common Dandelion and *Tragopogon* sp. Goat's Beard					0.063	
Aegopodium podagraria Goutweed	0.005				0.0017	
Other				0.0038	0.16	0.076

(compared to other insects) in England (Kendall and Solomon 1973).

Howe (1984) predicted that most mutualistic interactions would involve groups of animals at a taxonomic rank higher than the level of species. Even though the native bees were the most effective pollinators, they represented a large group, with 11 species. Therefore, the evolution of a tight mutualistic relationship between *V. opulus* var. *opulus* and one species of native bee is not very likely.

Acknowledgments

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Interrelationships of Fire History, Land Use History, and Landscape Pattern Within Pictured Rocks National Lakeshore, Michigan

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Forest fire history in Upper Michigan was studied using cross-sections from living fire scarred trees and 100 year old fire scarred stumps from Pictured Rocks National Lakeshore (PRNL). Prior to the late 19th century, surface fires were common within pine-dominated patches of very well-drained soils with an average fire occurrence rate of one per 21.8 years. Since the era of European settlement, there have been no significant forest fires within PRNL. This difference in fire occurrence likely involves changes in the influence of native peoples upon the landscape, in land use patterns and in the public policy and technology of fire control. Changes in vegetation structure attributable to patterns of fire and land use history are evident upon comparison of present vegetation characteristics and 19th century land line survey records. Patterns of fire occurrence for specific areas within PRNL possibly suggest that large scale landscape connectivity may also play a role in the fire regime.

Key Words: Fire history, land use history, landscape pattern, Upper Michigan.

The role of fire in ecosystem dynamics within the Great Lakes region has been the subject of much interest since the 1940s. The considerable influence of fire upon vegetation patterns in several areas of northern Minnesota, northern Lower Michigan, northern Wisconsin and southwestern Ontario has been documented (Maissurow 1941; Spurr 1954; Vogl 1970; Frissell 1973; Heinselman 1973; Cwynar 1977; Swain 1978; Van Wagner 1978; Simard and Blank 1982; Whitney 1986). Fire is important in the regeneration of Jack Pine (*Pinus banksiana*), Red Pine (*Pinus resinosa*), White Pine (*Pinus strobus*), Paper Birch (*Betula papyrifera*), Trembling Aspen (*Populus tremuloides*), and various other trees and shrubs of the region (Maissurow 1935; Cayford 1970; Van Wagner 1970; Heinselman 1973).

Since fire is a natural, often crucial, factor influencing much of the world's vegetation on a variable time scale, management of fire prone wild land vegetation on public lands must have a sound basis in fire ecology.

Pictured Rocks National Lakeshore (PRNL) is situated in the north central portion of Upper Michigan along the southern shore of Lake Superior (46° N, 86° W). The Lakeshore is a narrow 65 km long strip of shoreline between the communities of Munising and Grand Marais, Michigan (Figure 1). A primary management goal of this unit is the preservation and/or restoration of natural systems, including natural fire regimes.

PRNL lies within the "Great Lakes/Saint Lawrence Forest", transitional between eastern deciduous and boreal forests (Rowe 1972). Tracts of conifer and hardwood-dominated vegetation occur in a mosaic controlled by substrate, water table relationships and historic land use patterns (Curtis 1959; Read 1975; Frederick et al. 1976). Cambrian and early Ordovician sandstones covered with Pleistocene glacial debris constitute most soil parent material (Hamblin 1958; Berndt 1977; Farrand 1982). Exposed bedrock is common only adjacent to the Pictured Rocks cliffs and the drainages that penetrate them. The climate can be described as continental with a strong maritime influence exerted by Lake Superior. Snowfall averages 450 cm and total precipitation 65 cm. Despite generally humid climate, hot, dry spells, usually in the spring or fall, occur periodically (Karl et al. 1970).

The shoreline areas and major embayments are characterized by very well-drained sands (Rubicon and Shelldrake soil series [Davis 1985; Carey 1987]) supporting primarily conifers including Red Pine, White Pine, and Jack Pine. Areas frequently saturated with water are characterized by organic soils supporting heaths of Labrador Tea (*Ledum groenlandicum*), Bog Laurel (*Kalmia polifolia*), Leatherleaf (*Chamaedaphne calyculata*) and Bog Rosemary (*Andromeda glaucophylla*) or swamp forests of White Cedar (*Thuja occidentalis*) and Tag Alder (*Alnus rugosa*). Upland soils derived from various glacial deposits support deciduous forest dominated by American Beech (*Fagus grandifolia*) and Sugar Maple (*Acer saccharum*).

A striking feature of the physical geography of this portion of the Lake Superior shoreline is the distinct compartmentalization of environments.

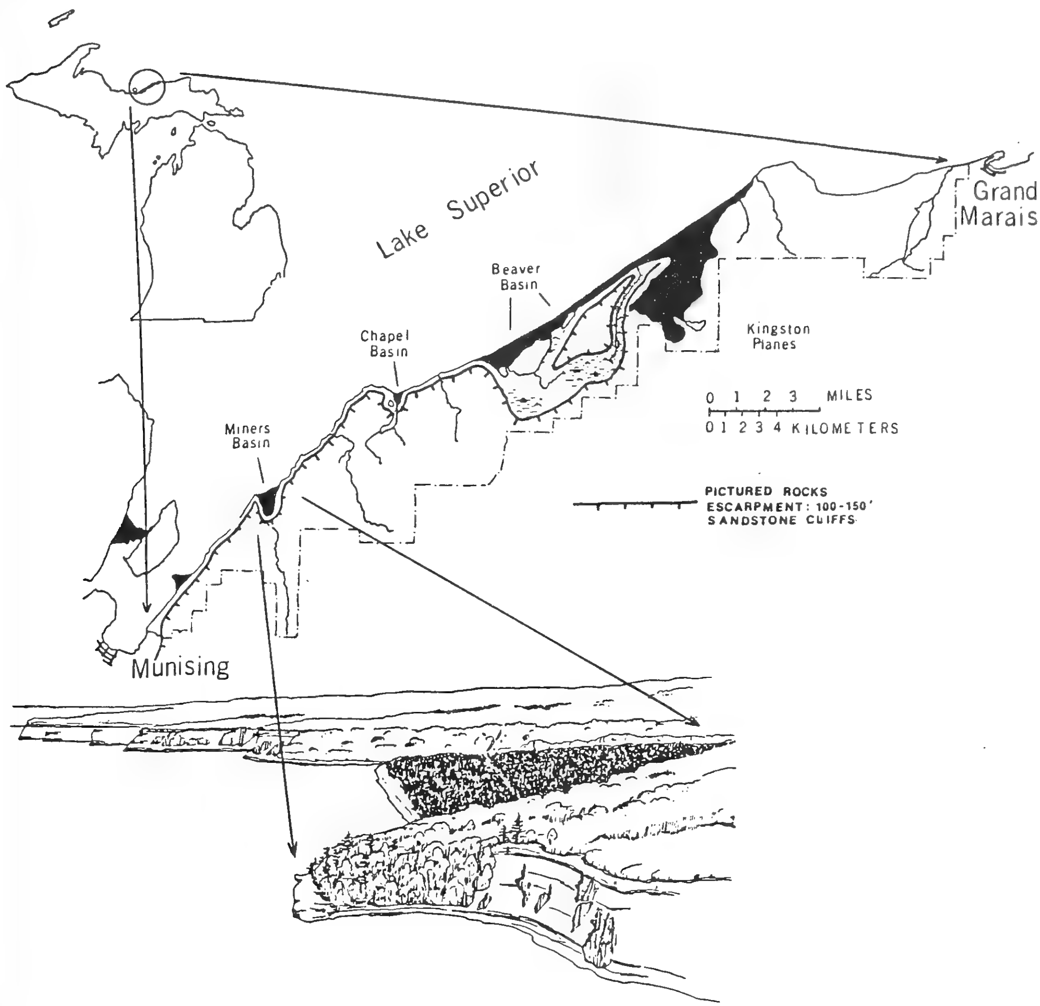

FIGURE 1. Geographic setting of Pictured Rocks National Lakeshore, MI; dark shading in first inset represents pine-dominated vegetation on excessively drained soils. Bottom inset shows view from the west of Miners Basin with typical topographic separation of upland hardwoods and low-lying pine stands.

Within the western one third of PRNL, several small patches of pine-dominated vegetation on coarse sandy soil occur within a larger mosaic of northern hardwood vegetation on somewhat loamy soil. These pine-dominated forests which occur a few meters above the level of Lake Superior are topographically separated from the upland hardwoods by steep escarpments 30 to 50 meters high (Figure 1).

Native peoples occupied the area at low densities prior to European settlement, utilizing fish and wildlife populations (Stonehouse 1981). Land use by colonizing Europeans around the turn of the twentieth century severely disrupted northern and northeastern forests (Pyne 1982; Cronon 1983; Russell 1983). Extensive logging of White and Red Pine occurred throughout the immediate area between 1885 and 1905 (Hall 1924; Stonehouse 1981). Clear and selective logging of hardwoods from the 1920s through the 1960s altered stand age structure; anthropogenic disturbance has affected virtually all forest vegetation of the study area (Frederick et al. 1977). With the establishment of Pictured Rocks National Lakeshore by congress in October, 1966, logging was eliminated within the park.

In this paper, I will attempt to examine the basic patterns of fire occurrence within PRNL during the pre- and post-settlement periods. This information should reveal clues to the major environmental and historical determinants of fire occurrence. An eventual goal is to develop

management plans for fire dependent vegetation within PRNL.

Methods

During the summers of 1984 and 1985, permanent transects were established throughout PRNL. Vegetation was sampled using the point centered quarters method (Cottam and Curtis 1956). An attempt was made to sample all soil-vegetation-geographic units within the Lakeshore. At least one vegetation transect was located within each quarter-section of the area. For each transect, ten random sampling points were positioned along a 100 meter tape; tree density and basal area and understory species presence were recorded for each point. In addition, microtopography, slope aspect, evidence of wildlife activity, and evidence of logging or fire were recorded. Transect locations were mapped on a 15′ topographic map.

Areas with fire evidence were revisited and partial cross sections of Red and White pine were cut from 100 fire-scarred logging era stumps and 25 living fire-scarred trees in the vicinity of sample points. Fire intervals were determined by examining sound sections (Arno and Sneck, 1977). A limited inventory of woody forest fuels (Brown 1974), was conducted. In addition, measures of duff and litter depth were recorded along fuel transects.

I found that most large diameter White and Red pines on excessively drained soils (Figure 1) are characterized by numerous unburned branches within a few inches of the ground surface. This configuration indicates that there has been no crown or surface fire during the tree's lifetime. Increment core ages of these trees thus give an estimate of time since the last fire. Presence of burned stumps and snags within a few meters of these trees throughout the sampled area confirms that major fires occurred prior to their establishment. Fire scars on the stumps represent a record of fire occurrence prior to establishment of most of the present forest.

Original notes from the mid-nineteenth century General Land Office (GLO) survey were examined to evaluate site specific changes in vegetation patterns. This method has been widely used in approximating composition of pre-settlement forests (Bourdo 1956; Frederick et al. 1977; Gordon 1969). William Burt established most exterior township lines in the region in 1841; William Ives and George Adair established the interior section lines between 1850 and 1855 (Frederick et al. 1977). The notes for the study area record bearing trees for section corners as well as trees that intersected the line by species and diameter. They also give general listings, by order of descending importance, of tree species that occur along the surveyed lines. As in Read (1975), plant nomenclature follows Voss (1972) for gymnosperms and monocots and Fernald (1950) for ferns, fern allies and dicots.

Results

Fire evidence was found almost exclusively on sandy, excessively drained soils of the Shelldrake and Rubicon soil series (Berndt 1977; Davis 1985; Carey 1987). Several burned snags and stumps were located within wetland areas and on rocky cliffs above excessively drained soils. No fire evidence was found in upland hardwood forests.

Of over 100 sections cut from logging era stumps, 40 were sound and determination of fire intervals was possible even after a century of exposure to the elements (Figure 2). Care was taken to consider only fire intervals clearly bracketed by fire scars. Sections from living and dead Red Pine were much better preserved than those of White Pine. White Pine sections tend to rot on scar faces making resolution of more than one scarring event difficult. A total of 116 samples of fire interval were derived from both sources.

FIGURE 2. Cross-section typical of those taken from fire scarred logging era stumps within PRNL.

Based on sections from living fire-scarred trees, the average period since the last scarring fire in PRNL was 84 years (Table 1). In contrast, the average pre-settlement fire occurrence rate was one per 21.8 years. A single section taken from a living Red Pine in the Beaver Lake area illustrates fire events from the early 18th century to the present, indicating a lengthening of fire interval in the 20th century (Figure 3). Fire scar evidence indicating a lack of fires since the 1910s is consistent with the increment core aging of large diameter individuals with unburned lower branches (Table 1).

Vegetation transects in areas with evidence of fire show a prominence of White Birch and Red Maple along with pine species (Table 2). While both these hardwood species are mentioned in the GLO survey notes (Table 3), it can be inferred that they were not nearly as prevalent in 1850 as they are at present. Increment core ages of larger diameter White Birch (all less than 80 years) are consistent with post settlement establishment. No other clear changes in the gross character of the forest overstory are evident.

The understory (Table 4) contains species typical of other fire prone forest stands of the region (Martin 1959; Curtis 1959), including blueberries, *Vaccinium angustifolium* and *Vaccinium myrtilloides*, Trailing Arbutus, *Epigaea repens*, Wintergreen, *Gaultheria procumbens*, Cow Wheat, *Melampyrum lineare*, Wild Lily of the Valley, *Maianthemum canadense*, Braken Fern, *Pteridium aquilinum* and Star Flower, *Trientalis borealis*.

Woody ground fuel loading measurements averaged 1.70 (sd = 1.35) tons/ac. (n = 17) while depth of needle litter accumulation and duff thickness averaged 1.38 in. (sd = 1.23) and 1.12 in. (sd = 0.76) respectively. Fuel data show high variability and no consistent geographic trends.

In scattered patches (about 10% of the study area), young Black Spruce and Balsam Fir form dense ladder fuels in the understory of Red and White pine (Figure 4). More prominent is a rather open understory where these species are absent or low and scattered (Figure 5). Ladder fuels in Jack Pine are well developed in most of the Miners Basin area.

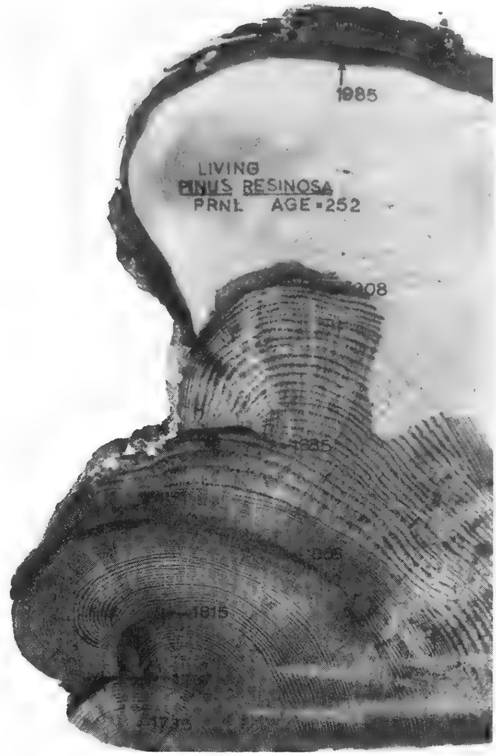

FIGURE 3. Section taken from a living *Pinus resinosa* within PRNL; most recent fire interval = 77 years; average of all previous intervals (5) = 28.2 years.

Discussion

Primary edaphic control on the distribution of fire-prone pine-dominated vegetation at PRNL is consistent with other studies within the region (Read 1975; Swain 1981; Whitney 1986). The strong correlation between coarse sand substrate

TABLE 1. Pre- and post-settlement fire occurrence for two areas of fire prone vegetation within PRNL. Data taken from wedges cut from live trees, cross-sections of logging era stumps, and increment borings. Mean, standard deviation and (sample size) are given for each entry.

Area	yrs. since last scar		ave. of all previous fire intervals		inc. borer age trees w/unburned lower branches	
Topographically isolated pockets (western PRNL)	87.3	13.2 (13)	29.8'	14.4 (21)	71.5	14.1 (31)
Topographically joined areas (central PRNL)	80.4	11.3 (12)	20.6	12.11 (70)	66.6	14.3 (50)
Entire area	84.0	12.6 (25)	21.8	12.5 (91)	68.7	14.3 (81)

TABLE 2. Summary of tree species characteristics for the 32 transects which contained fire evidence within PRNL.

Species	Average importance value (Curtis 1959)	Overstory Constancy	Understory Constancy
Betula papyrifera	0.68	0.84	0.31
Pinus banksiana	0.56	0.28	0.16
Pinus strobus	0.54	0.72	0.56
Pinus resinosa	0.47	0.63	0.22
Acer rubrum	0.30	0.81	0.78
Tsuga canadensis	0.13	0.13	0.06
Abies balsamea	0.09	0.38	0.34
Picea mariana	0.06	0.25	0.09
Quercus rubra	0.05	0.25	0.34
Populus grandidentata	0.03	0.19	0.06
Acer saccharum	0.02	0.06	0.06
Betula alleghaniensis	0.02	0.09	0.03
Fagus grandifolia	0.01	0.09	0.13
Picea glauca	0.01	0.06	0.00
Populus tremuloides	0.01	0.09	0.00
Prunus serotina	0.00	0.03	0.00
Acer pensylvanicum	0.00	0.00	0.09
Thuja occidentalis	0.00	0.00	0.03

and pine in northern Michigan and northern Wisconsin has apparently been consistent over the past 9000 years (Brubaker 1975). Lack of fire evidence in northern hardwood soil/vegetation does not mean that fire played no role there. Fire may have influenced northern hardwoods dynamics on return periods on the order of 1000 years (Graham 1941; Whitney 1986). PRNL wetlands undoubtedly burned periodically during pre-settlement time. Wetland fires during drought in Upper Michigan and in other parts of the eastern U.S. are well documented (Cypert 1961; Klukas 1972; Johnson 1976; Heinselman 1978; Anderson 1982).

Although they provide some dendrochronological data, logging-era stump sections have obvious limitations. Because outer cambial rings of some stumps burned, absolute aging, the development of detailed fire chronology, and reconstruction of individual fire extent (Heinselman 1973) have not been possible. Since evidence of some fires has likely been obscured, the intervals in Table 1

TABLE 3. Prominence of species recorded in General Land Office survey notes (1841-1850) for areas with fire evidence within and immediately adjacent to PRNL. Up to ten species are mentioned in describing vegetation adjacent to each line. For each line description, first mention implies most prominence, last mention, least prominence.

Species	% of line trees' witness trees	total mentions in line descriptions	1st-4th mention in line descriptions
Pinus strobus	34	21	17
Pinus resinosa	21	14	11
Tsuga canadensis	13	16	15
Picea mariana	11	16	11
Pinus banksiana	5	2	2
Fagus grandifolia	4	11	3
Abies balsamea	3	9	7
Acer rubrum	2	14	7
Betula alleghaniensis	2	9	6
Betula papyrifera	2	7	1
Thuja occidentalis	1	1	0
Acer saccharum	0	5	1
Quercus rubrum	0	3	1

TABLE 4. Characteristics of nonarboreal understory of the 32 transects which contained fire evidence within PRNL.

Shrubs	Average Frequency	Constancy	Constancy-Frequency Index (F × C)
Amelanchier sp.	0.31	0.25	0.077
Corylus cornuta	0.15	0.06	0.009
Gaylussacia baccata	0.48	0.19	0.091
Hudsonia tomentosa	0.10	0.03	0.003
Lonicera sp.	0.80	0.03	0.024
Sorbus sp.	0.02	0.03	0.001
Vaccinium angustifolium	0.51	0.75	0.382
Vaccinium myrtilloides	0.70	0.97	0.679
HERBS, FERNS AND GRASSES			
Apocynum androsaemifolium	0.13	0.09	0.012
Aralia nudicaulis	0.02	0.06	0.001
Carex sp.	0.33	0.09	0.030
Chimaphila umbellata	0.17	0.09	0.015
Cladonia rangiferina	0.60	0.66	0.396
Clintonia borialis	0.22	0.16	0.035
Coptis groenlandica	0.15	0.06	0.009
Cornus canadensis	0.22	0.12	0.026
Cypripedium acaule	0.13	0.19	0.025
Deschampsia flexuosa	0.35	0.12	0.042
Dryopteris disjuncta	0.10	0.03	0.003
Epigaea repens	0.32	0.53	0.170
Gaultheria hispidula	0.10	0.03	0.003
Gaultheria procumbens	0.73	0.87	0.635
Goodyera sp.	0.10	0.03	0.003
Linnaea borealis	0.20	0.03	0.006
Lycopodium inundatum	0.20	0.03	0.006
Lycopodium lucidulum	0.38	0.16	0.061
Melampyrum lineare	0.57	0.47	0.268
Maianthemum canadense	0.31	0.31	0.096
Osmunda cinnamomea	0.07	0.03	0.002
Oxalis montana	0.70	0.03	0.021
Pteridium aquilinum	0.88	0.94	0.827
Pyrola sp.	0.30	0.03	0.009
Trientalis borealis	0.34	0.31	0.105

probably underestimate true pre-logging fire occurrence. The fire record gleaned from logging era stumps is restricted to the period from about 1650 A.D. to the time of settlement.

Given their topographic isolation and small size, I initially hypothesized that the pre-settlement fire occurrence rate within the pockets of pine-dominated vegetation along Lake Superior would be lower than in larger, more continuous tracts of similar vegetation. On the contrary, the rate of fire occurrence in these patches was found to be quite similar to those reported elsewhere in unbroken topography (Van Wagner 1971; Frissell 1973; Cwynar 1977; Alexander, Mason and Stocks 1979; Alexander 1980; Heinselman 1981; Simard and Blank 1982). Heinselman (1978, 1981) distinguished between two types of fire in Red Pine: very hot stand replacing fires (return period 120-150 years) and cooler ground fires that sweep through the understory every 20-30 years. Fires discussed in this study are of the latter type.

What was the ignition source for these fires? Lightning caused fires occur at a rate of about 2 to 12 per million hectares per year in Upper Michigan (Schroeder and Buck 1970. p. 168). It is difficult to visualize individual lightning strikes in each of the pine-dominated pockets of PRNL (each 100 to 200 hectares) to account for each fire. Although lightning starts certainly occurred, I suggest that lightning ignition was supplemented by activities of the Native American population. All of the pine-dominated pockets within the study area occur near stream mouths with immediate access to Lake Superior, places that native people occupied on a seasonal basis before European settlement (Stonehouse 1981; Griffin 1986). Although there are few direct references in the local and regional literature to fire dispersal by native peoples or

FIGURE 4. Ladder fuels of black spruce and balsam fir occasional in scattered patches within the Beaver Basin portion of the study area.

seventeenth century traders, accidental and/or intentional ignitions must have occurred (Agassiz and Cabot 1850: page 73; Day 1953; Curtis 1959; Thwaites 1959; Cronon 1983; Russell 1983).

Post-settlement increase in Paper Birch and Red Maple is attributable to sprouting after the harvest and fires around the turn of the 20th century. Both White Birch and Red Maple are vigorous sprouters but are also quite sensitive to fire; large individuals are killed by even moderate fires (Fowells 1965). Red Maple has maintained or, perhaps, increased in importance since the "cutover" because of its ability to sprout from root stocks and its intermediate shade tolerance, an advantage as forest succession proceeds in the absence of fire. Despite the lack of fires over the last 70-80 years, an increase in shade tolerant conifers is not evident.

GLO notes indicate that the 130 hectare Miners Basin supported a mixed stand of White and Red pine in 1841. The surveyors make no mention of *Pinus banksiana* and recorded: "below (Miners) lake and between the hills is a strip of pine plains timbered with a scattering of yellow (surveyors' term for Red Pine) and White Pine running to Lake Superior." This area is now a nearly pure stand of Jack Pine. In contrast, Beaver Basin retained its components of Red and White Pine, despite harvest and slash fires starting in 1893. One can speculate that these patterns are a result of differences in degree of harvest and severity of slash fires. A prime reason for decline of Red Pine in the lake states following the turn of the century harvest was the lack of seed trees remaining to furnish seed to mineral soil sites created by fire (Ahlgren and Ahlgren 1983). Sandy sites that support a mixture of pine species may be converted to Jack Pine stands as a result of repeated and/or severe crown fire (Cayford 1970; Ahlgren 1973). Miners Basin, perhaps due to its proximity to centers of settlement, may have been subject to more thorough harvest of mature Red Pine and/or more intense slash fires than that in the Beaver Basin area.

Large scale changes in cover type (e.g. mixed pine to aspen) did not occur within PRNL as they did in some areas of western and extreme eastern Upper Michigan, northern Wisconsin and northern Minnesota (Curtis 1959; Ferris 1980; Ahlgren and Ahlgren 1983; Albert, Denton and Barnes 1986).

Despite the lack of recent fire, present ground fuel levels are not heavy. Total fuel accumulations are roughly similar to those found by Brown (1966) and Alban (1977) in natural Red Pine stands in Minnesota and Michigan; woody debris and needle litter values at PRNL are about twice those of cited studies while duff values are somewhat lower. Increment corings of Black Spruce and Balsam Fir indicate the scattered prominence of ladder fuels formed by these species has developed since logging occurred around 1900. Heinselman (1978) suggests that fire occurrence in "near boreal" conifers is more a function of climatic condition than of stand age and fuel loading. The pre-settlement 20 to 30 year ground fire cycle in Red Pine correlates well with recent regional drought as defined by the Palmer Drought Index in Michigan (Karl et al. 1983). However, Lorimer and Gough (1988) found that, for pine lands in northern Wisconsin, dry conditions necessary for surface fires occur almost every year. Pyne (1984) suggests that "most surface fires spread through fine fuels . . . low fuel moistures for these size classes do not require drought." Interaction of ignition factors (associated with both lightning and humans) and common meteorological conditions were likely responsible for frequent surface fires in the study area prior to European settlement. I suggest that the disruption of this interaction as well as changes in land use pattern associated with settlement and extensive logging and the onset of

FIGURE 5. Typical aspect of vegetation within the Beaver Basin portion of the study area.

institutional fire suppression are responsible for the observed differences in rates of fire occurrence.

The influences of physical geography upon disturbance pattern and landscape patch linkage have been demonstrated in diverse vegetation types (Swain 1980; Forman and Godron 1981; Romme and Knight 1982; Canham and Loucks 1984; Pickett and White 1985; Whitney 1986). Analysis of landscape pattern and connectivities among vegetation patches may have some utility in explaining fire occurrence in central portions of central Upper Michigan including the study area. Although mean values for "pre-settlement" fire occurrence do not differ significantly among sample localities within PRNL, there is a trend toward more frequent fires in the central as compared to the western portion of the area (Table 1). Pine patches in western PRNL are topographically isolated from adjacent upland northern hardwood forests, while topographic barriers between vegetation patches are less prominent in central PRNL. This latter arrangement may promote a higher degree of landscape connectivity with regard to fire. A 25 000 hectare expanse of pine-dominated vegetation lies immediately to the southeast of the Shelldrake and Rubicon soils within central PRNL and the adjacent Kingston Plains (Figure 6). The annual probability of a lightning or human caused ignition somewhere in this larger area is considerably higher than that within the pine pockets. During a regional drought in pre-settlement times, such a fire would occasionally spread to the edge of, and into, the easternmost pine pockets along narrow corridors of pine-dominated vegetation. The westernmost pockets are isolated topographically and would not have been subject to this additional source of ignition. There may have been additional pre-settlement linkage of the pine pockets along the Lake Superior shore with wetland and other vegetation to the south. The watershed of the Manistique River occupies a 250 000 hectare sandy glacial lake plain (Farrand 1982; Albert, Denton and Barnes 1986) south of the Kingston Plains and PRNL. Periods of high temperatures and low humidity that bring extreme fire weather are generally accompanied with south or southwest winds. A single ignition in this low relief area during drought may have periodically spread fire northward within its mosaic of marshlands and pine plains. A reconnaissance of portions of the Manistique River watershed was accomplished during the summer of 1988. Many burned snags within wetlands and trees and logging era stumps with multiple fire scars within isolated strips of pine dominated vegetation were located.

This investigation at PRNL provides a basic outline of fire history and dynamics and identifies portions of the park where fire has influenced vegetation on a short time scale. Fire management plans and prescriptions to meet agency objectives must take into account natural and anthropogenic

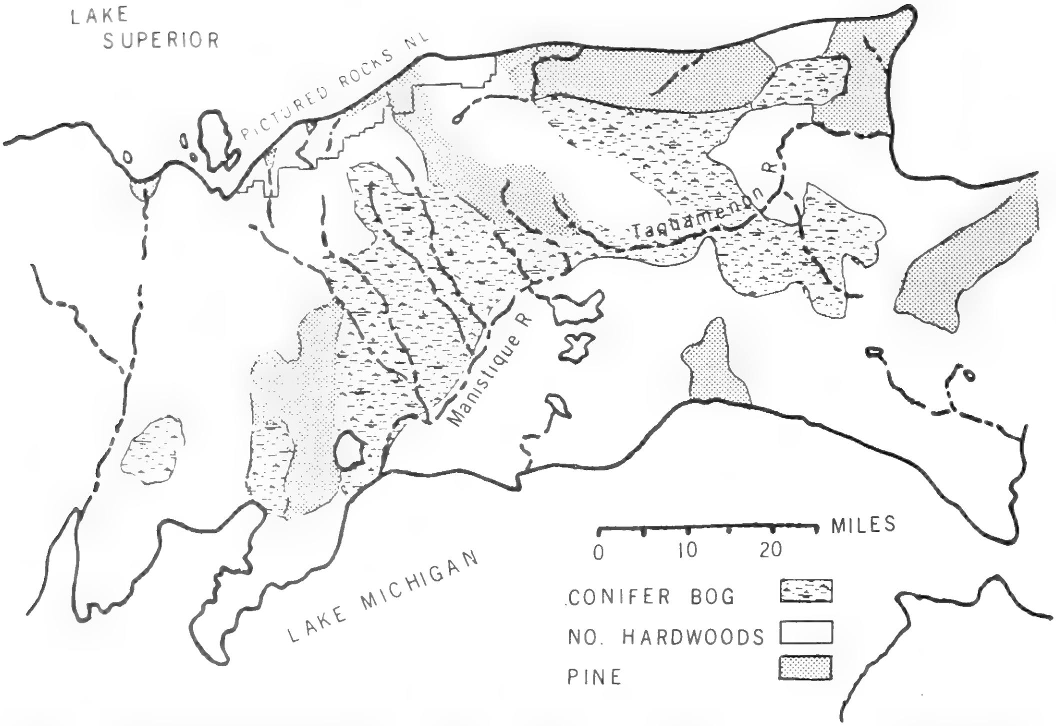

FIGURE 6. Vegetation map of central Upper Michigan showing units discussed in the text (after Kuchler, 1964). Note the isolated "pineland pockets" along the Lake Superior shoreline within PRNL.

changes in vegetation structure that have occurred over the past 75-100 years.

Several additional investigations must be undertaken before a fire plan can be formulated and implemented to mimic and/or restore a semblance of the natural fire regime. Chief among these will be a detailed inventory and analysis of fuels and fuel dynamics.

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Common Loon, *Gavia immer*, Productivity on a Northern Wisconsin Impoundment

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Belant, Jerrold L., and Raymond K. Anderson. 1991. Common Loon, *Gavia immer*, productivity on a northern Wisconsin impoundment. Canadian Field-Naturalist 105(1): 29–33.

Common Loon productivity was determined during 1986-1987 for the Turtle-Flambeau Flowage (TFF), a 5798 ha impoundment in northern Wisconsin. Nest success (61%, n = 44) and chicks fledged/breeding pair (0.87) was high compared to other North American studies. Major causes of nest failure were predation (41%) and water level fluctuations (24%). The Common Loon population on the TFF appears stable or increasing.

Key Words: Common Loon, *Gavia immer,* nest characteristics, productivity, Wisconsin.

The breeding range of the Common Loon (*Gavia immer*) has receded northward to the northern fringe of the United States (Bent 1919; Palmer 1962). The reduction in range appears to be related to increased shoreline development and recreational pressure (Plunkett 1979).

Productivity studies have been conducted throughout the breeding range of the Common Loon (McIntyre 1975; Sutcliffe 1980; Titus and VanDruff 1981; Yonge 1981). Common causes of nest failure include fluctuating water levels (Barr 1986; Fair 1979; Sutcliffe 1979a), human disturbance (Sawyer 1979; Titus and VanDruff 1981), and predation (McIntyre 1975; Olson and Marshall 1952; Sutcliffe 1980).

Predation has been identified as a major cause of nest failure in many studies (Olson and Marshall 1952; McIntyre 1975; Metcalf 1979; Sutcliffe 1979a; Titus and Vandruff 1981; Yonge 1981; Douglas and Reimchen 1988). McIntyre (1975) and Sutcliffe (1979a) attributed the majority of nest losses to Raccoons (*Procyon lotor*). McIntyre (1975) also identified Skunks (*Mephitis mephitis*) as predators of loon eggs. Olson and Marshall (1952) reported that potential mammalian predators include Mink (*Mustela vison*) and Otters (*Lutra canadensis*). Avian depredation by Common Crows (*Corvus brachyrynchos*) (McIntyre 1975; Ream 1976) and Ravens (*Corvus corax*) (Ream 1976) has also been reported.

Zimmer (1982) reported the status and distribution of the Common Loon in Wisconsin but did not intensively evaluate productivity. The objective of this study was to determine productivity of the Common Loon on an impoundment in northern Wisconsin.

Study Area and Methods

The study was conducted on the Turtle-Flambeau Flowage (TFF) a 5798-ha impoundment in northern Wisconsin (46°00′N, 90°10′W). The TFF was inundated in 1928. The shoreline is predominantly upland with an additional 2575 ha of wetland adjoining the flowage basin. The TFF contains >150 islands and has 290-km of shoreline. Maximum depth is 16 m; $\geq 50\%$ of the TFF is < 3 m in depth. Drawdown occurs from November-March and is recharged from snowmelt during March-April. Water levels generally drop 65-100 cm between May and August. Summer homes and resorts occupy $< 5\%$ of mainland shoreline. Predominant recreational use within the TFF includes fishing and camping, with greatest activity adjacent to areas of human occupancy.

The TFF was surveyed intensively from a boat from late-April through July 1986, and from May through July 1987, to locate territorial pairs and nest sites. Nesting loons were disturbed once briefly during incubation to determine clutch size and measure nest site characteristics (Sutcliffe 1980). Nests were approached by boat to minimize shoreline activity. Nest type was categorized as hummock (on grass or stump hummocks, or abandoned Beaver lodges), scrape (usually in sand, gravel, or leaves), constructed (built of bottom detritus and/or aquatic vegetation), or artificial platform (Mathisen 1969; McIntyre and Mathisen 1977; Sutcliffe 1979a; Douglas and Reichem 1988). Platforms were constructed similarly to those described by Douglas and Reichem (1988).

A nesting attempt was considered successful if ≥ 1 egg hatched. Hatching success is defined as the number of eggs hatched/total number of eggs. Fledging success is the number of chicks ≥ 8 weeks of age/number of chicks hatched.

Incubating loons were monitored for at least 2 hr/week, at a distance, to determine nest success; unsuccessful nests were examined for causes of failure. Nest reuse was defined as loons nesting

exactly on a previous nest site. Nest predators were determined from field sign, eg. tracks, hair, scat, eggshell breakage (Reardon 1951). Broods were monitored at least weekly to determine chick survival and fledging rates. Water level fluctuations were monitored daily with a permanent, calibrated staff positioned in the TFF. Human activity near the nest was rated as high, medium, or low, based on the number of boats observed during nest monitoring that passed within 50 m of the nest. High, medium, and low human activity represents > 1.0 disturbances/hr, $1.0 \geq X > 0.5$ disturbances/hr, and ≤ 0.5 disturbances/hr, respectively. Chi-square statistics were computed to determine effects on productivity and nest site selection.

Results

The TFF harbored 22 territorial pairs in 1986 and 23 in 1987. Seventeen and 21 territorial pairs attempted nesting during 1986 and 1987, respectively. Forty-four nesting attempts, including six renests were recorded during the study. The period of nest construction and incubation ranged from early May to late June in both years.

Loon nest sites were established on mainland, island, and artificial platforms. Island nests were more common (n = 28, 64%) than mainland (n = 8, 18%) or platform sites (n = 8, 18%) (Table 1). At least 1 island apparently suitable for nesting was within 400 m of each mainland nest. Platforms were available to 7 breeding pairs each year. Nest islands ranged from 0.001 ha to 1.08 ha in size; 13 (46%) nest islands were < 0.01 ha. There was no significant difference between nest success on different size islands ($\chi^2 = 2.52$, P = 0.11).

Constructed and scrape nests each comprised 41% (n = 14) of natural nests observed, and hummock nests comprised 18% (n = 6). Island nest types included 13 constructed, 9 scrape, and 6 hummock (3 were on abandoned Beaver lodges). Mainland nest sites included 1 constructed and 5 scrape.

Vegetation types occurring most frequently within 1 m of nests were woody shrubs including Steeplebush (*Spirea tomentosa*), willow (*Salix* spp.), and Labrador Tea (*Ledum groenlandicum*) and sedges (*Carex* spp.). Woody shrubs occurred at 88% of natural nest sites and sedges occurred at 76% of nest sites. Bottom detritus or terrestrial substrate was present in all natural nests. Terrestrial and aquatic roots, twigs, and leaves also were used extensively, each occurring in $\geq 65\%$ of nests.

Distance of nests to water ranged from 04–286 cm (Table 2). Scrape nests averaged further from the water than constructed or hummock nests. In 52% (n = 22) of all cases, loons could submerge within 0.6 m of shoreline. There was no significant difference ($\chi^2 = 0.78$, P = 0.38) between nest success and shoreline water depth.

Nests that were exposed to < 200 m of fetch had a higher success rate (63%, n = 38) than nests exposed to ≥ 200 m of fetch (25%, n = 4). Of 28 island nests sites, 19 (68%) were located on shorelines facing the nearest mainland.

Nests located in areas of low human activity were less successful (45%, n = 11) than nests with medium (62%, n = 26) or high (80%, n = 5). The distance of nests to the nearest human development ranged from 30-1430 m. Fifteen (34%) nests were located within 400 m of human development and 29 (66%) nests were greater than 400 m. There was no significant difference ($\chi^2 = 0.72$, P = 0.40) between nest success and distance to human development.

Minimum hatching success for all eggs was $\geq 51\%$. Minimum hatching success was $\geq 67\%$ for eggs in mainland nests (n = 13–15), the number of eggs in two nests that produced one young each was undetermined, 52% (n = 48) for island nests, and 31% (n = 16) for eggs on platforms. No significant difference between hatching success of island, mainland, and platform eggs ($\chi^2 = 4.24$, P = 0.12) was detected.

Twenty-seven of 44 nest attempts (61%) produced ≥ 1 young. Mainland nests were more successful (75%, n = 8) than platforms (63%, n = 8) or island nest sites (57%, n = 28). Renest attempts were 50% (n = 6) successful. No natural nest sites

TABLE 1. Type and location of natural Common Loon nests, Turtle-Flambeau Flowage, Wisconsin 1986-1987.

	Mainland				Island			
Year	Con.[a]	Hum.	Scr.	unk.	Con.	Hum.	Scr.	Total
1986	0	0	4	1	5	2	3	15
1987	1	0	1	1	8	4	6	21
Total	1	0	5	2	13	6	9	36

[a]Con. = constructed, Hum. = Hummock, Scr. = Scrape, unk. = unknown.

TABLE 2. Characteristics of 34 natural Common Loon nests, Turtle-Flambeau Flowage, Wisconsin 1986-1987.

Characteristic (cm)	Nest Type			
	Constructed (n = 14)	Scrape (n = 14)	Hummock (n = 6)	Combined (n = 34)
Height above water				
mean	17.5	15.0	14.0	16.0
SE	1.12	1.98	2.11	1.01
Distance to water				
mean	13.0	54.0	0.0	22.0
SE	7.46	18.85	—	9.05
Nest diameter				
mean	65.0	50.0	62.0	58.0
SE	3.69	3.93	4.09	2.59
Bowl diameter				
mean	32.0	33.0	29.0	32.0
SE	0.74	1.46	1.83	0.76
Bowl depth				
mean	5.0	2.4	3.5	3.5
SE	0.45	0.45	0.67	0.33

used in 1986 were reused in 1987 and only one instance of renesting at the same site occurred within the same year. Platform reuse was 75% (n = 4) between years.

Major causes of nest failure included a 12 cm water level increase during 1987 (n = 4), mammalian predation (n = 4) and avian predation (n = 3). Mink scat and hair were found in the bowl of 1 depredated nest and tracks were at the site of another. Of seven known nest predations, six occurred on island sites and one on a mainland site. Two nests on artificial platforms were abandoned. The cause of four nest failures was undetermined.

Fledging success was 90% in 1986 and 75% in 1987 ($\bar{x}$ = 83%). The number of chicks fledged/nesting pair was 1.06 in 1986, 0.71 in 1987 ($\bar{x}$ = 0.87); the number of chicks fledged/territorial pair was 0.82 in 1986 and 0.65 in 1987 ($\bar{x}$ = 0.73).

Discussion

Island nest site use was lower (63%) than reported elsewhere, even though suitable island nest sites were available in all territories. However, if combined with platforms, 82% could be considered island nest sites. Several studies have indicated that islands were preferred loon nest sites (McIntyre 1975; Munro 1945; Olson and Marshall 1952; Strong 1985; Sutcliffe 1980; Vermeer 1973a, 1973b). Reported use of island nest sites ranged from 69-97% in other studies (McIntyre 1975; Olson and Marshall 1952; Smith 1981; Sutcliffe 1980; Vermeer 1973b). Sutcliffe (1980) reported 69% use of islands, attributing low use to a lack of available island nest sites. Islands may provide certain features (e.g. protection from wave action, inaccessability to predators) which could influence nest site selection. Forty-six percent of islands used for nesting were $\leq$ 0.01 ha and 93% were $\leq$ 0.4 ha. Sutcliffe (1980) reported 71% of islands used were less than 0.4 ha, and Vermeer (1973b) reported that 76% of nesting islands were $\leq$ 0.8 ha.

Loons in this study used materials immediately adjacent to the nest site for nest construction. Similar results were reported by Olson and Marshall (1952) and Sutcliffe (1980). Strong (1985) suggested that characteristics of the surrounding area may be more important in nest site selection than immediate nest site characteristics.

Distance of nests to water did not affect success in this study. Sutcliffe (1980) reported nest failure when receding water levels increased the distance of the nest to water by 3 m. Fair (1979) suggested that nest abandonment, due to lower water levels, was more a result of recently exposed obstructions hindering movement than increased horizontal distance. All loons in this study had unobstructed access from the nest to water. Although a 20 cm water level decline did not affect nest success, a 12 cm water level increase during a brief period of the 1987 nesting season accounted for the flooding and abandonment of four nests, with no attempts to renest. Barr (1986) found 33% more clutches hatched successfully in territories with water level fluctuations < 1.5 m.

Our results suggest that loons can adapt to human presence; this is advantageous for species survival throughout much of its breeding range. Heimberger et al. (1983) suggested that some loons may become habituated to human disturbance. McIntyre (1975) noted a significant, positive correlation between increased recreational use and nest success and brood size. Sutcluffe (1980)

indicated that loons will adapt to some environmental changes, including increased human recreation. However, Titus and VanDruff (1981) and Heimberger et al. (1983) suggested that the intensity and frequency of human disturbance could have a negative impact on loon production and Sawyer (1979) concluded that human disturbance was a major cause of nest failure.

Low hatch success on platforms may in part be attributed to design. Common loon eggs hatch asynchronously with the first chick often leaving the nest before the second chick hatches (McIntyre 1975). During one observation, a chick was unable to remount the platform while the adult incubated the remaining egg. The adult subsequently abandoned the egg to attend the chick. As a result, wooden ramps were placed on platforms during 1987 to allow chicks to remount the nest which improved hatch success by 13% (n = 8).

Strong (1987) reported 59% of nesting attempts in old nest bowls, and McIntyre (1975) reported 30% reuse. The lack of natural nest site reuse between years in this study undoubtedly was caused by 50–60 cm lower water levels during 1987. This modified shoreline microhabitat and rendered previous nest sites unattractive.

Predation was the primary cause of nest failure on the TFF, accounting for 64% of known losses, 57% was attributed to mammalian and 43% to avian predation. Potential avian and mammalian predators include Crows, Ravens, gulls (*Larus* spp.), Mink, Raccoon, Skunk, and Red Fox (*Vulpes vulpes*). The islands on which three of four known mammalian predations occurred were < 20 m from the mainland, allowing easy access by shoreline predators, particularly Mink and Raccoon.

The number of territorial pairs (22 in 1986, 23 in 1987) and low mean density (approximately one territorial pair/260 ha) indicates that the loon population on the TFF is stable or increasing. The observed productivity of 1.06 chicks hatched/breeding pair and fledging success of 83% is higher than that reported by Sutcliffe (1980), who suggested that a loon population can be sustained or increased at production levels between 0.50 and 0.79 chicks hatched/breeding pair. Nest success and chicks fledged/breeding pair was high compared to other North American studies (Olson and Marshall 1952; Vermeer 1973b; McIntyre 1978; Metcalf 1979; Sawyer 1979; Trivelpiece et al. 1979; Sutcliffe 1980; Smith 1981; Titus and VanDruff 1981; Yonge 1981; Parker et al. 1986) which may in part be attributed to low human use, low breeding pair density, and low predation.

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The Effect of Regulated Lake Levels on Muskrats, *Ondatra zibethicus*, in Voyageurs National Park, Minnesota

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Population characteristics and radio-marking of Muskrats from two water regimes were used to assess the impacts of regulated lake levels in Voyageurs National Park, Minnesota. Annual water fluctuations in Rainy Lake and Kabetogama Lake average 1.0 and 2.7 m respectively, with high water in summer and early fall followed by a winter drawdown. During 1985-1987, significantly greater Muskrat density was indicated in Rainy Lake based on spring 1986 sign survey, fall 1986 trapnight success and house counts for 1985-86 and 1986-1987. All other density estimates indicated greater numbers in Rainy Lake. Muskrat weights differed significantly between areas in spring 1986; other body measurements did not differ significantly. Survival of radio-marked Muskrats was very low in both areas, especially during freeze-up in early winter.

Key Words: Muskrat, *Ondatra zibethicus*, lake levels, Voyageurs National Park, populations, telemetry.

Several studies have shown adverse effects of summer water drawdowns on Muskrats. Errington (1939) suggested that Muskrats abandoned home ranges and that Mink (*Mustela vison*) predation increased with drought in summer and fall. Bellrose and Brown (1941) found water stability to be more important than vegetation changes caused by low water in August-October. Donahoe (1966) compared Muskrat densities in diked areas to those where water levels changed with weather. Diked areas supported more Muskrats, which was attributed more to reduction of mortality than reproductive responses. Proulx and Gilbert (1983) found home range and number of houses Muskrat family increased as water decreased through summer. This study aimed to determine if the density and morphology of Muskrats in suitable habitats of the Voyageurs National Park, Minnesota, were influenced by severe winter drawdowns.

Study Area

Voyageurs National Park (48°36′N, 93°25′W) lies along the Minnesota-Ontario border and is part of a large system of lakes (Figure 1). This nearly 89 000 ha park is 39% water with four large lakes and 26 small interior lakes (Kallemeyn 1983). It is underlain by the Canadian Shield and has numerous small islands in the larger lakes. Middle and eastern portions have rocky shorelines, while the western end is flat enough to allow broad marshes. Average annual snowfall is about 140 cm with daily average temperatures in January of 16.1°C (Cole 1987). Temperatures range from 40° to 36°C (Kurmis et al. 1986).

Water levels on the park's major lakes are controlled by industry-owned dams located outside park boundaries. A dam on Rainy River, the outlet for Rainy Lake, has been in operation since 1909, while the dams regulating the levels of Namakan Reservoir have been operating since 1914. The lake levels are regulated by the International Joint Commission (IJC) for the authorized purposes of navigation, hydroelectric power, fish spawning, flood control, and pollution abatement (Kallemeyn 1987). Before dams were built in the early 1900s, natural annual fluctuation probably averaged 1.9 m throughout this lake system (Flug 1986). Currently, one lake fluctuates only 1 m annually while the others fluctuate about 2.7 m (Flug 1986). The greatest drawdown, in Namakan Reservoir (Kabetogama, Namakan, and Sand Point Lakes), occurs during winter with progressive declines continuing through February and March. Highest water levels are maintained from June through September (Figure 2).

The forests in the park are typical of southern boreal regions. Marshes and streams contained cattail (*Typha* sp.), burreed (*Sparganium* sp.), horsetail (*Equisetum* sp.), sedges (*Carex* sp.), Wild Rice (*Zizania aquatica*) and other species.

Materials and Methods

Study sites

Topographic maps and surveys were used to select study sites (Figure 1) with similar depths, vegetation, and topography. In Rainy Lake (minimal drawdown), study sites included two bays (Cranberry and Black) and one creek (Alder), while in Kabetogama Lake (significant drawdown)

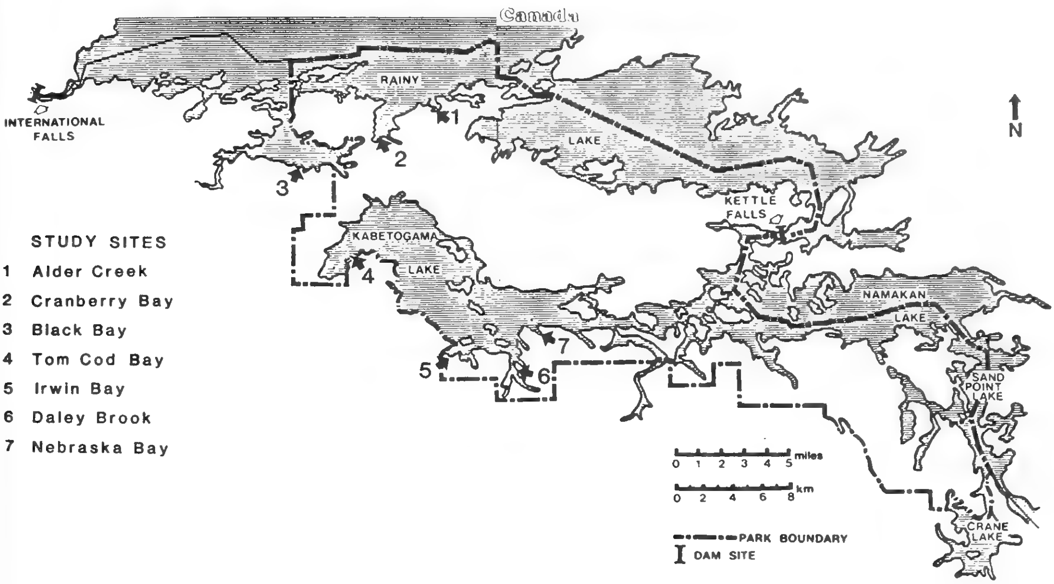

FIGURE 1. Voyageurs National Park and study site locations.

three bays (Tom Cod, Nebraska, and Irwin) and one creek (Daley Brook) were selected. Both creeks had mouths with the characteristics of a small bay with a few cattail beds present.

Trapping

Muskrats were live-trapped in fall (September-November) 1985 and 1986, and spring (May-June) 1986 with baited Tomahawk traps (National Trap

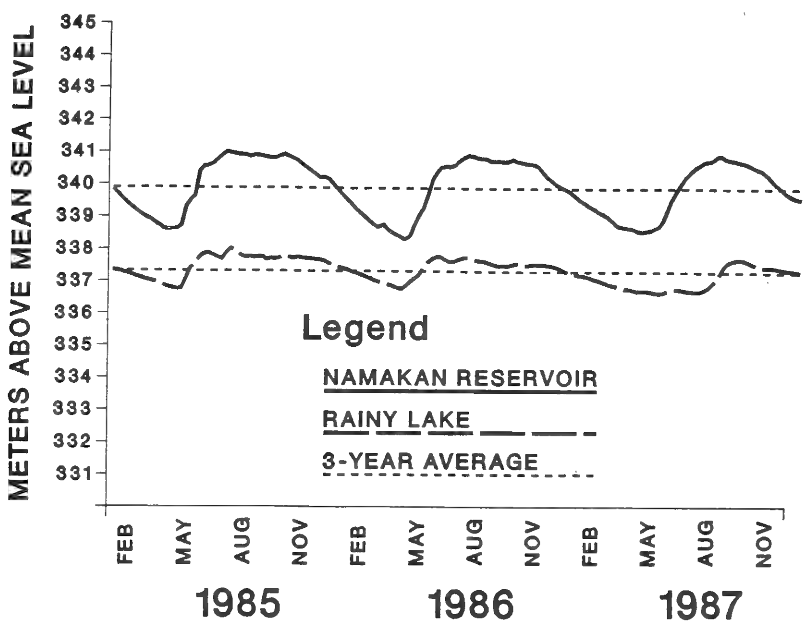

FIGURE 2. Weekly average water levels for Namakan Reservoir and Rainy Lake, Voyageurs National Park for 1985-1987 (data from Lake of the Woods Control Board).

Company, Tomahawk, Wisconsin). One or two traps were placed on all Muskrat houses, and additional traps were placed near runways, feeding platforms, and defecation sites. Animals were not anesthetized unless they were to be radio-marked. Captured Muskrats were weighed and standard body measurements (zygomatic breadth, body length, tail length, and right hind foot length) taken. Anus to urinary papilla (AP) measurements were also taken to determine if sexes differed. Monel #1 ear tags (National Band and Tag Company, Newport, Kentucky) were attached to one ear on all trapped Muskrats.

Trapnight success (total captures/total trapnights, excluding recaptures and their respective trapnights) and population estimates were determined from trapping data. The study sites in each region consisted of discrete sub-areas with no capture overlap. Estimates of the number of Muskrats/house were obtained from trapping seven houses in each lake in fall 1986 until no new Muskrats were captured for at least two consecutive nights.

Sign Surveys

Sign surveys provided indices of Muskrat density in spring and fall 1986, and fall 1987. All feeding platforms, tracks, and defecation sites were counted as sign. Spring surveys were done on foot after the lake ice melted. The survey lines were either subdivided into portions hiked in a day (1986) or marked into equal sections with alternate portions counted (1987). The fall surveys were done by canoe and subdivided for analysis into portions done each day.

House Counts

As an additional index of population levels, Muskrat houses were counted in winter from skis or snowmobile. In 1984-1985, counts were made in Daley Brook and Black, Cranberry, and Irwin bays. In 1985-1986, Irwin Bay was omitted, but Tom Cod and Alder Creek were added. In 1986-1987, all of the above areas were counted. Subdivisions within these areas were identical to those used for analysis of capture data.

Radiotelemetry

In September and October 1985, temperature-sensitive transmitters (Telonics, Inc., Mesa, Arizona) were surgically implanted in ten Muskrats using methoxyflurane (Metafane) as an inhalant anesthesia. Only five Muskrats survived longer than two weeks, and in September and October 1986, activity-sensitive radio-collars (Wildlife Materials, Inc.) were utilized in an attempt to reduce handling mortality. Eleven Muskrats were radio-marked (again using methoxyflurane). There were no mortalities related to handling.

All radio-marked Muskrats were located at least twice weekly until the signal could not be found for three consecutive attempts or the Muskrat died. Death was assumed when a constant body temperature was less than 38°C (1985) or there was no activity for three location attempts (1986). An effort was made to recover all carcasses to determine cause of death.

Data analyses

A multivariate analysis of variance (MANOVA) was used to compare standard body and AP measurements in relation to sex and area. Significant ($\alpha = 0.05$) differences were investigated further with analysis of variance (ANOVA) to determine which dependent variables were responsible for the difference. ANOVA was used for comparing most density indices. Area differences in sex ratio were evaluated using Chi-square tests.

Population estimates (N*) using capture-recapture information were calculated with the modified Lincoln-Peterson formula (Seber 1986)

$$N^* = \frac{(n_1 + 1)(n_2 + 1)}{(m_2 + 1)} - 1$$

where n_1 = the total captures in the initial trapping period, n_2 = the total captures in the second trapping period, and m_2 = the number of marked animals in the second capture period. Initial captures were defined as those occurring in the first 2-4 days of a trapping period, which varied from 4 to 10 days in length; the second trapping period included all subsequent trapping. Sub-areas with sufficient recapture data were used for density estimates. Kabetogama and Rainy lakes were compared using the Mann-Whitney U-test (Conover 1971).

It should be noted that interspersion of treatments is not possible in this study, therefore we can only say that the areas differ (Hurlbert 1984). Causes of the difference can only be inferred from observations and are not demonstrated or refuted by the significance tests.

Results

Sex ratios and body measurements

Proportions of males and females did not differ significantly between lakes. In spring 1986, 67% (n = 21) of the Muskrats captured were males; in fall 1986, 62% (n = 143) were males. The fall sex ratio (both lakes) differed significantly from 50:50 ($\chi^2 = 7.16$, $P < 0.01$). The sample size from spring was too small to detect differences.

Kabetogama Lake Muskrats were significantly lighter in spring 1986 ($P < 0.005$) and only slightly heavier than Rainy Lake Muskrats in the fall (Table 1). In spring 1986, zygomatic breadth was significantly smaller ($P < 0.005$) in Kabetogama

TABLE 1. Mean Muskrat weights (g) and density comparisons by population estimates, trapnight success, sign surveys and house counts for Kabetogama and Rainy lakes, Voyageurs National Park, 1985-1987.

	Kabetogama Lake			Rainy Lake		
	$\bar{x}$	S.E.	n	$\bar{x}$	S.E.	n
Mean weights						
Fall 1985	911	28.1	56	902	38.8	29
Spring 1986[a]	951	34.2	8	1081	31.2	13
Fall 1986	872	26.8	45	828	22.9	100
Population estimates[b]						
Fall 1985	0.25	0.05	2	0.93	0.14	2
Fall 1986	0.59	0.27	3	1.45	0.29	5
Trapnight success[c]						
Fall 1985	0.22	0.06	17	0.26	0.08	7
Spring 1986	0.04	0.01	10	0.08	0.03	7
Fall 1986[d]	0.14	0.03	9	0.35	0.04	16
Sign Surveys[e]						
Spring 1986[f]	0.14	1.18	21	0.35	1.93	15
Fall 1986	19.79	6.23	16	27.67	4.79	15
Spring 1987	0.00	0.00	9	1.15	5.77	5
House Counts[g]						
Winter 1985-1986	0.05	0.02	13	0.14	0.03	24
Winter 1986-1987	0.21	0.05	13	0.33	0.06	19

[a]Differences between Kabetogama and Rainy lakes were significant at $P < 0.005$.
[b]Muskrats/hectare of emergent vegetation, n = number of sub-areas counted. Mean ha/sub-area varied from 10.6–44.4.
[c]Total captures/total trapnights, n = number of sub-areas; mean trapnights per sub-area ranged from 14.57–32.22.
[d]Differences between Kabetogama and Rainy lakes were significant at $P < 0.005$.
[e]Sign/kilometer, n = number of intervals hiked; mean interval length varied from 0.37–0.86 km.
[f]Differences between Kabetogama and Rainy lakes were significant at $P < 0.025$.
[g]Houses/hectare of emergent vegetation, n = number of sub-areas counted; mean ha/sub-area varied from 10.75–14.78. Counts are for Tom Cod Bay in Kabetogama Lake and Cranberry Bay in Rainy Lake only. Differences between bays were significant at $P < 0.05$ for both years.

Lake Muskrats ($\bar{x} = 39.0$ mm, SE = 0.92 n = 8) than in Rainy Lake Muskrats ($\bar{x} = 42.4$ mm, SE = 0.38, n = 13). No significant differences were found in other standard body measurements between lakes, bays within lakes, or gender.

Anus to urinary papilla (AP) measurements were significantly greater in males than females ($P < 0.005$) in spring and fall 1986. Males and females differed more in Kabetagoma Lake than in Rainy Lake ($P < 0.001$) in the fall (Table 2).

TABLE 2. Anus to urinary papilla measurement (mm) of Muskrats from Kabetogama and Rainy lakes, Voyageurs National Park, spring and fall 1986.

	Anus to urinary papilla measurement (mm)					
	Kabetogama Lake			Rainy Lake		
	$\bar{x}$	S.E.	n	$\bar{x}$	S.E.	n
Spring 1986						
Males[a]	30.5	2.36	6	31.5	1.75	8
Females	16.0	1.00	2	16.6	0.75	5
Females 1986[b]						
Males	20.4	0.56	25	18.3	0.29	61
Females	14.4	0.41	19	15.6	0.32	36

[a]Males and females differed significantly at $P < 0.0005$, both seasons.
[b]Kabetogama and Rainy lake males differed significantly at $P < 0.001$.

Tukey's pairwise comparison procedure with unequal sample sizes (Zar 1984) showed that males differed ($P < 0.001$), but females did not ($P > 0.20$). Spring 1986 measurements did not differ between lakes, but spring males had an obviously greater AP measurement than fall males.

Density estimates

Population density for Rainy Lake Muskrats (based on mark-recapture) was more than twice that in Kabetogama in both 1985 and 1986 (Table 1). Differences were not significant, however, ($P > 0.10$), because of the small sample sizes and large variance.

Trapnight success also indicated greater Muskrat numbers in Rainy Lake (Table 1). Trapping success in Kabetogama ranged from 42 to 84% of the Rainy Lake level. Differences were significant in fall 1986 ($P < 0.005$).

No recaptures were made in spring of the previous fall-caught Muskrats in either Kabetogama or Rainy lakes. Survival to adulthood of Muskrats in Ontario studies was only 32% in two studies (Boutin et al. 1988; Proulx and Gilbert 1983). Spring captures in Kabetogama Lake appeared to be comprised solely of recent immigrants. Only one Muskrat was caught in the first week of the trapping period when the water elevation was 0.03 m below to 0.32 m above the three year average. Maximum summer elevation was 1.04 m above the three year average. Subsequent captures (7) occurred after the water had risen to 0.36 m above average and cattail roots were submerged. Also, all houses were dry and Muskrat signs were not found until higher water levels prevailed. In Rainy Lake, 8 captures were made during the first week of trapping (water elevation was 0.41 - 0.45 m above the three year average; maximum summer elevation = 0.46 m above average) and all houses were in at least 0.45 m of water at the start of the trapping period.

Lake differences in Muskrat sign abundance (Table 1) were significant in spring 1986 ($P < 0.025$), when almost no sign could be found in Kabetogama Lake. Again, in fall 1987, more Muskrat sign was encountered in Rainy Lake than in Kabetogama Lake. In spring 1987, both lakes were exceptionally dry through June (Figure 2) and very little sign could be found in either area.

In all study sites, Rainy Lake had greater (but non-significant) densities of Muskrat houses during the three winters. Houses were significantly more abundant in large, marshy bays of Rainy Lake than in comparable bays in Kabetogama Lake (Table 1). House counts in Cranberry Bay (Rainy Lake) were greater than those in Tom Cod Bay (Kabetogama Lake) in both years (T-test, $P < 0.05$ in both years).

Muskrat colony size also contributed to greater Muskrat density in Rainy Lake than in Kabetogama Lake. Colony size in Cranberry Bay on Rainy Lake ($\bar{x}$ = 4.7 Muskrats/house, S.E. = 0.62, n = 7) was substantially greater than in Kabetogama Lake ($\bar{x}$ = 2.0 Muskrats/house, S.E. = 0.34, n = 7).

Radiotelemetry

Twenty-one Muskrats were radio-marked in 1985 and 1986 (Table 3). In 1985, four survived until persistent ice cover and two of these survived at least into January 1986. In fall 1986, nine Muskrats survived until persistent ice cover, with none remaining beyond December.

Telemetry did not adequately reveal overwinter movements because mortality was so high, but a few Muskrat fates are noteworthy. Three Kabetogama Muskrats died in burrows that became dry at the time of freeze-up, while no Rainy Lake Muskrats suffered that fate. Another Kabetogama Lake Muskrat remained near its capture location until water levels receded in late January, 1985. Its house was 20 m from water at the time; we lost radio contact nine days after it began extensive movements.

Predation is suspected in the deaths of one Kabetogama and four Rainy Lake Muskrats because of Otter or Mink invasion of houses where the Muskrat bones were found (three Muskrats), a bent and chewed collar (one Muskrat), and location of one carcass in an aspen tree cavity. These animals could also have been scavenged. Predation (by canid or felid) on one Muskrat was confirmed by the U.S. Fish Wildlife Health

TABLE 3. Numbers of fates of radioed Muskrats in Kabetogama and Rainy lakes, Voyageurs National Park, 1985-1986.

	Kabetogama Lake		Rainy Lake	
Fate of Muskrat	1985	1986	1985	1986
handling-related death[a]	3	0	3	0
Lost radio contact	0	4	0	0
Died in dry burrow	2	1	0	0
Moved when water receded[b]	1	0	0	0
Moved when water stable	0	0	1	0
Preyed upon or scavenged[c]	0	1	0	4
Confirmed predation	0	0	0	1

[a]Died within two weeks of handling.
[b]Lost contact after sudden increase in movement.
[c]Most found in house or burrow, with varying evidence for predation.

Laboratory, Madison, Wisconsin. Bald Eagle(*Haliaeetus leucocephalus*) predation of an unradioed Muskrat above ice was documented once in Kabetogama Lake in January 1987.

Discussion

Body measurements

Seasonal and area differences in AP measurement among males (fall 1986) probably reflects testes size and reproductive status. Beer and Meyer (1951) found that adult male testes reached a maximum weight in May, receded during August to November, and were quiescent from December to February. Males are not likely to differ between lakes in the spring because all are reproductively active. In fall, however, male AP measurements in Kabetogama Lake were greater than those in Rainy Lake, suggesting an extended breeding season. Errington (1951, 1961) found females had more litters at lower densities and/or when early litters were unsuccessful. However, colony size was lower in Kabetogama Lake; even with a possible extension of the breeding season, summer survival or litter size may be low. Only five recaptures were made in the fall of spring-caught Muskrats, all in Rainy Lake.

The lighter weight of Kabetogama Muskrats in spring 1986 may be due to poor condition or to a higher proportion of young animals. Smaller zygomatic breadth measurements suggest the latter. General condition of Kabetogama Lake Muskrats in other respects did not seem as good as those from Rainy Lake. Of 45 Muskrats captured in Kabetogama Lake in fall 1986, five (11%) had abnormalities more severe than minor cuts; one had a leg that hung limp, one had a hard, swollen abscess in its cheek, two had cleft lips, and one had an extra anus. Only one of 95 (1%) Muskrats captured in Rainy Lake exhibited any abnormality (abcess). Dispersing animals may be more likely to be juveniles, in poor condition, or social outcasts (Errington 1939; Lidicker 1975; Keith et al. 1984). The lighter weight of Muskrats and the lack of Muskrat captures and sign in Kabetogama Lake in early spring, along with the abnormalities of the animals (whether genetic or environmentally caused) suggest that Kabetogama Lake may be acting as a "dispersal sink" (Lidicker 1975) each year.

Density indices

Drawdown effects were suggested by the trend toward lower Muskrat numbers in Kabetogama Lake for all density indices, with significant differences in trapnight success (fall 1986), sign surveys (spring 1986), and house counts in the larger, marshy bays (1985-1986, 1986-1987). In 1987, both areas were dry in spring because of drought, and conditions on Rainy Lake were similar to those occurring every year on Kabetogama Lake. The detrimental effects on Muskrat can be seen in the results of the sign survey for that season.

Muskrat density estimates in both lakes were low (Errington 1939; Proulx and Gilbert 1983; Clay and Clark 1985), possibly because suitable habitat is not extensive in Voyageurs National Park. House counts in both areas were also lower than in other studies (Bellrose and Brown 1941; Donahoe 1966).

Danell (1978) and Proulx and Gilbert (1984) found that Muskrats abandoned houses and constructed new ones as water receded in summer and fall. This leads to an overestimation of active house numbers in winter counts (Proulx and Gilbert 1984). In both fall trapping seasons at the park, Muskrats in Kabetogama Lake constructed new houses in deeper water as lake levels gradually lowered before freeze-up in October and November. This behavior was not seen in Rainy Lake. The difference in number of active houses between the two areas may actually be greater than reported.

The cattail areas near Muskrat houses were at water depths of $<$ 1 m during summer (Kallemeyn 1987) and most submergent vegetation was at depths of $<$ 1.2 m (Kallemeyn, personal communication). Water levels in Kabetogama Lake began to decline in October and reached minimum levels from February to April (Figure 2). In winter, water levels may drop to 1.59 m below average, well below the submergent vegetation zone. This means that in the harshest part of winter Muskrats cannot reach their food supply by water, are exposed to predation if they try to reach it overland, and will most likely find the food source frozen under several centimeters of ice if they succeed. Although Rainy Lake often drops 1 m or more in winter, the length of time water levels are below the cattail areas is much shorter and thus Muskrats can probably survive on submergent vegetation.

Radiotelemetry

Survival of radio-marked Muskrats in both lakes was especially low during freeze-up. Push-up sites (domes of submergent vegetation piled over cracks or holes in the ice) are typically not made until persistent ice cover is well established (Dozier 1948), so this protection from predators for above ice activity would not be available during freeze-up. It is not known if the radio-collars contributed to Muskrat vulnerability to predators at this time.

It is possible that water drawdown led to increased predation pressure in Kabetogama Lake, and this may partially explain the lack of Muskrats in this lake in the spring. Errington (1939) found that Muskrats foraged much more on top of the ice when burrows and houses became dry, giving them

more exposure to predators. They were also preyed upon when they tried to remain in exposed burrows. After ice-out in spring, wide mud flats with long exposed burrow systems were seen in Daley Brook and Tom Cod Bay. Several Muskrat carcasses were found in small nests in these systems, a few with associated Mink scats. A similar situation was not found in Rainy Lake until 1987, when drought led to exposed mud flats in both areas. There is no evidence that Mink can limit Muskrat populations in secure habitats (Errington 1939; Wilson 1954), but they can contribute to the demise of populations under stress from drought and/or freeze-out (Errington 1939; Proulx et al. 1987).

In summary, Rainy Lake supported significantly greater densities of Muskrats than Kabetogama Lake, based on all available indices. Although not all population estimates and density indices showed statistically significant differences, there was a consistent trend toward higher Muskrat densities where water levels were most stable in winter. Where water drawdown occurred in winter, inaccessible food sources and predation were implicated as possible sources of mortality. Although interspersion of treatments was not possible in this study, similarity of habitats in other apsects lead us to believe water depth is a major year-around modifier in the distribution and abundance of this semi-aquatic mammal.

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Bryophytes of the Wager Bay Region, District of Keewatin, Northwest Territories

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George W. Scotter. 1991. Bryophytes of the Wager Bay Region, District of Keewatin, Northwest Territories. Canadian Field-Naturalist. 105(1): 41–44.

Thirteen taxa of Hepaticae and 82 taxa of Musci were collected from the Wager Bay region, Northwest Territories. *Grimmia ovalis* and *Blindia acuta* are reported for the continental Northwest Territories for the first time. Most of the other collections of bryophytes represent the first records for the Wager Bay region.

Key Words: Bryophytes, new records, Wager Bay, District of Keewatin, Northwest Territories.

Wager Bay is located in the northeastern section of the District of Keewatin between latitudes 65° and 66° N and longitudes 87° and 91° W. A natural resource survey of the region was undertaken by George W. Scotter and Geoffrey L. Holroyd of the Canadian Wildlife Service and by Stephen C. Zoltai of the Canadian Forestry Service during 1984 because of its potential as a possible new national park. The Wager Bay area is considered to be representative of the central tundra region of the Canadian Shield, referred to as natural region 16 by the Canadian Parks Service. The bryophyte flora of the Wager Bay region is virtually unknown. The nearest published records are from the Thelon River (Scotter 1966; Holmen and Scotter 1967) and the Keewatin District (Zoltai and Johnson 1978). The purpose of this paper is to report the bryophytes collected by Scotter during the 1984 survey. The collection was as thorough as field time allowed. Most of the bryophytes reported represent the first records for the Wager Bay region.

A description of the study area, geology, landforms, climate and vegetation is provided in Cody et al. (1989). In the course of the survey, 21 sites were studied. Those sites and the data on collection localities are the same as mapped and listed for the vascular plants (Cody et al. 1989).

In the list of bryophytes which follows, the collection numbers are mine. The locality number is given in parentheses following the collection number. The voucher collections have been deposited in the herbarium of the New York Botanical Garden (NY). The taxonomy follows Stotler and Crandall-Stotler (1977) and Ireland et al. (1987). Except for the Sphagnaceae, which were identified by Dr. Richard E. Andrus, State University of New York at Binghamton, all identifications were by the late Dr. William C. Steere unless otherwise indicated.

HEPATICAE

PSEUDOLEPICOLEACEAE

Blepharostoma trichophyllum (L.) Dum. 76332, 76371(1); 76529(11).

PTILIDIACEAE

Ptilidium ciliare (L.) Hampe 76380(1); 76483(7); 76562(14).

CEPHALOZIACEAE

Cephalozia bicuspidata (L.) Dum. 76592(19).

Cephalozia pleniceps (Aust.) Lindb. 76428(3).

CEPHALOZIELLACEAE

Cephaloziella arctica Bryhn & Douin 76336(1); 76447(3); 76531(12); 76583(17).

JUNGERMANNIACEAE

Anastrophyllum minutum (Schreb.) Schust. 76374(1); 76382, 76385(2); 76565(16).

Chandonanthus setiformis (Ehrh.) Lindb. 76425(3); 76518(11); 76600(20).

Gymnocolea inflata (Huds.) Dum. 76362(1); 76449(3).

GYMNOMITRIACEAE

Gymnomitrion concinnatum (Lightf.) Corda 76595(20).

Gymnomitrion corallioides Nees 76345(1); 76448(3); 76571, 76579(17).

Marsupella revoluta (Nees) Dum. 76577(17).

SCAPANIACEAE

Scapania irrigua (Nees) Gott. 76391(2).

MARCHANTIACEAE

Marchantia polymorpha L. 76540(12).

MUSCI

SPHAGNACEAE

Sphagnum aongstroemii C. Hartm. 76438(3); 76460, 76462(4); 76478, 76566(16); 76589, 76590(18).

Sphagnum arcticum Flatb. & Frisv. 76437(3); 73467(4). This is the second report of *Sphagnum*

arcticum in Canada, the other being from the Aklavik region (Flatberg and Frisvoll 1984).

Sphagnum balticum (Russ.) C. Jens. 76431, 76437, 76441(3); 76464, 76468(4); 76495, 76499(8); 76590, 76591(18).

Sphagnum compactum DC. *ex* Lam. & DC. 76419, 76437, 76439(3); 76464, 76465(4).

Sphaghnum fimbriatum Wils. *in* Wils. & Hook. *f.* 76345, 76368, 76375(1); 76389, 76393, 76410, 76413, 76414, 76415(2); 76420, 76439 (3); 76460(4); 76499 (8); 76519(11); 76551(12).

Sphagnum imbricatum Hornsch. *ex* Russ. 76422, 76473(3).

Sphagnum lenense Lindb. *f. ex* Pohle 76468(4); 76591(18).

Sphagnum lindbergii Schimp. *ex* Lindb. 76440(3); 76459, 76461(4).

Sphagnum orientale Sav.-Ljub. 76420(3); 76544(12); 76574(17). This species was first reported from Bathurst Inlet by Steere and Scotter (1986).

Sphagnum rubellum Wils. 76420, 76424, 76437, 76439(3); 76463, 76468(4); 76489(7).

Sphagnum russowii Warnst. 76460, 76464(4); 76479(6).

Sphagnum squarrosum Crome 76402(2); 766423, 76437(3); 76469(4); 76497, 76498(8); 76506(9); 76541(12).

Sphagnum teres (Schimp.) Aongster *ex* C. Hartm. 76550(12).

ANDREAEACEAE

Andreaea rupestris Hedw. 76430(3), 76450(3); 76516(11); 76582(17).

DITRICHACEAE

Ceratodon purpureus (Hedw.) Brid. 76348(1); 76387, 76405, 76407(2); 76530, 76535, 76537(12).

Ditrichum flexicaule (Schwaegr.) Hampe 76452(3).

SELIGERIACEAE

Blindia acuta (Hedw.) B.S.G. 76517(11). New to the continental Northwest Territories based on Ireland et al. (1987). *Blindia acuta* is known from the Arctic Archipelago, Newfoundland, Labrador, Quebec, Ontario, Alberta, British Columbia and the Yukon. It has not been reported from Manitoba or Saskatchewan. This identification was confirmed by D. H. Vitt.

DICRANACEAE

Cnestrum alpestre (Hub.) Nyh. *ex*. Mogensen = Syn. *Cynodontium alpestre* (Hüb.) Milde. 76351(1).

Cynodontium strumiferum (Hedw.) Lindb. 76480(6); 76533, 76546(12).

Dicranella crispa (Hedw.) Schimp. 76543(12). This identification was made by D. H. Vitt.

Dicranum angustum Lindb. 76381(2); 76470, 76473(6).

Dicranum elongatum Schleich. *ex* Schwaegr. 76358, 76374(1); 76385(2); 76458(4); 76476(6); 76488, 76494(7); 76500(9); 76515(10); 76570(17).

Dicranum fuscescens Sm. 76388, 76400(2); 76454(3); 76490(7).

Oncophorus wahlenbergii Brid. 76334, 76342, 76369(1); 76381, 76383(2); 76446(3); 76466(6); 76487(7); 76569(16); 76594(20).

POTTIACEAE

Anoectangium sendtnerianum B.S.G. 76523(1).

Tortella tortuosa (Hedw.) Limpr. 76484(7).

Tortula ruralis (Hedw.) Gaertn., Meyer & Scherb. 76379(1);

GRIMMIACEAE

Grimmia affinis Hoppe & Hornsch. *ex* Hornsch. 76584(17).

Grimmia ovalis (Hedw.) Lindb. 76514(10); 76559(13); 76581(17). New to the continental Northwest Territories based on Ireland et al. (1987). The species is known from the Arctic Archipelago, Labrador, Quebec, and British Columbia. Identification confirmed by R. I. Hastings.

Grimmia torquata Hornsch. *ex* Grev. 76573, 76580(17).

Rhacomitrium canescens (Hedw.) Brid. 76407(2).

Rhacomitrium lanuginosum (Hedw.) Brid. 76378(1); 76432(3); 76486(7); 76561(14); 76576(17).

Schistidium agassizii Sull. & Lesq. *ex* Sull. 76513(10).

Schistidium apocarpum (Hedw.) B. & S. *in* B.S.G. 76524(11); 76603(21).

Schistidium rivulare (Brid.) Podp. 76335(1); 76521(11).

SPLACHNACEAE

Aplodon wormskjoldii (Hornem.) R.Br. 76352(1).

Splachnum sphaericum Hedw. 76357(1); 76404(2); 76538(12).

Splachnum vasculosum Hedw. 76406(2); 76534(12).

Tetraplodon mnioides (Hedw.) B.S.G. 76337(1); 76387, 76399, 76409(2); 76535(12); 76578(17); 76593(19).

Tetraplodon paradoxus (R.Br.) Hag. 76338, 76353, 76355, 76367, 76373(1)

BRYACEAE

Bryum argenteum Hedw. 76553(12); 76557(13).

Bryum cyclophyllum (Schwaegr.) B.S.G. 76505(9).

Bryum knowltonii Barnes 76349(1).

Bryum pseudotriquetrum (Hedw.) Gaertn., Meyer & Scherb. 76390(2).

Bryum stenotrichum C. Mull. 76339(1); 76417(2); 76427(3); 76554(12).

Bryum weigelii Spreng. 76526(11).

Pohlia cruda (Hedw.) Lindb. 76365(1); 76510(9); 76598(20).

Pohlia nutans (Hedw.) Lindb. 76545(12).

MNIACEAE

Cinclidium latifolium Lindb. 76333, 76346(1).

Cinclidium stygium Sw. 76418(2).

Cinclidium subrotundum Lindb. 76370(1); 76394(2); 76472(6); 76599(20).

Plagiomnium ellipticum (Brid.) Kop. 76376(1); 76502, 76510(9).

AULACOMNIACEAE

Aulacomnium palustre (Hedw.) Schwaegr. 76404, 76411(2); 76453(3).

Aulacomnium turgidum (Wahlenb.) Schwaegr. 76396, 76412, 76416(2); 76475, 76477, 76482(6); 76492(7); 76522(11).

MEESIACEAE

Meesia triquetra (Richt.) Aongstr. 76330, 76331, 76344, 76364(1).

Meesia uliginosa Hedw. 76356, 76363(1).

CATOSCOPIACEAE

Catoscopium nigritum (Hedw.) Brid. 76596(20).

BARTRAMIACEAE

Bartramia pomiformis Hedw. 76536(12).

Conostomum tetragonum (Hedw.) Lindb. 76372(1); 76451(3); 76568(16); 76575(17); 76597(20).

Philonotis fontana (Hedw.) Brid. 76386, 76398(2); 76507(9).

ORTHOTRICHACEAE

Orthotrichum anomalum Hedw. 76377(1).

Ulota curvifolia (Wahlenb.) Lilj. 76586(17). This identification was made by D. H. Vitt.

AMBLYSTEGIACEAE

Calliergon giganteum (Schimp.) Kindb. 76403(2); 76445(3).

Calliergon obtusifolium Karcz. 76360(1).

Calliergon richardsonii (Mitt.) Kinb. *ex* Warnst. 76340, 76359(1); 76386, 76392, 76401, 76406(2).

Calliergon sarmentosum (Wahlenb.) Kindb. 76347(1); 76421, 76434(3); 76457(4), 76493(7); 76520(11).

Calliergon stramineum (Brid.) Kindb. 76341(1); 76433(3); 76501(9); 76547(12).

Calliergon trifarium (Web. & Mohr) Kindb. 76602(21).

Campylium stellatum (Hedw.) C. Jens. 76418(2).

Drepanocladus aduncus (Hedw.) Warnst. 76354(1); 76549(12).

Drepanocladus exannulatus (B.S.G.) Warnst. 76435, 76445(3); 76504(9); 76532, 76539, 76548(12).

Drepanocladus revolvens (Sw.) Warnst. 76331, 76343, 76350(1); 76395, 76408(2); 76474(6); 76493(7); 76520, 76528(11).

Drepanocladus uncinatus (Hedw.) Warnst. 76361, 76366(1); 76397(2); 76442(3); 76542(12).

Hygrohypnum polare (Lindb.) Loeske 76525(11).

Scorpidium scorpioides (Hedw.) Limpr. 76601(21).

PLAGIOTHECIACEAE

Plagiothecium denticulatum (Hedw.) B.S.G. 76511(9).

HYLOCOMIACEAE

Hylocomium splendens (Hedw.) B.S.G. 76485(7); 76572, 76585(17).

POLYTRICHACEAE

Pogonatum dentatum (Brid.) Brid. 76426(3).

Polytrichum commune Hedw. 76455, 76456(4); 76509(9); 76532(12); 76567(16).

Polytrichum juniperinum Hedw. 76429, 76436(3); 76471(6); 76503(9); 76507(11); 76537, 76552(12); 76560(13); 76570, 76587(17).

Polytrichum piliferum Hedw. 76503(9); 76556(13); 76563(16).

Polytrichum strictum Brid. 76384(2); 76443(3); 76481(6); 76490(7); 76558(13); 76564(16); 76588(18).

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Common Loon, *Gavia immer*, Nesting Success and Young Survival in Northwestern Ontario

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Croskery, Peter Ross. 1991. Common Loon, *Gavia immer*, nesting success and young survival in northwestern Ontario. Canadian Field-Naturalist 105(1): 45–48.

Hatch out and chick survival were determined from 326 Common Loon eggs in 193 nests in northwestern Ontario. Two-thirds of all eggs hatched and approximately half of those resulted in fledged young. On average 1.69 eggs/nest were deposited with a mean hatch of 0.99 eggs/nest. Fledging success was 0.61 young/nesting pair. Both egg loss and chick mortality were equal factors affecting recruitment.

Key Words: Common Loon, *Gavia immer*, hatch success, chick mortality, nesting success, Ontario, breeding biology.

One of the most important factors affecting the maintenance of any avian population is the species' ability to successfully hatch and raise young to fledging. In avifaunal populations, there appear to be two important periods in the survival and recruitment of young: first, the loss of eggs and secondly, the loss of young following hatch and prior to fledging. In precocial species such as the Common Loon (*Gavia immer*), the survival of eggs and the survival of young can be affected by very different mortality factors since the eggs are confined to a nest but the young are mobile.

A combination of traditional nest site location (McIntyre 1975; Titus and VanDruff 1981; Strong 1985) and poor nest concealment (Sutcliffe 1980) result in high egg predation of Common Loon nests. Vulnerability to nest predation is further increased by the relatively long incubation period (29 days). Following hatch, young are fully covered in downy feathers and leave the nest within 24 h (Barr 1973). However, they require considerable parental care (Palmer 1962; Olsen and Marshall 1954) and are extremely vulnerable to a variety of predators. Mortality is high during the first two weeks of life but decreases after that period (Bundy 1976). After four weeks of age, mortality of young loons is infrequent (McIntyre 1983).

This study was designed to examine the significance of egg loss and chick mortality, as factors affecting Common Loon productivity in northwestern Ontario.

Methods

This study was completed on 40 lakes near Ignace, Ontario (49°25'N; 91°40'W). The study area is located on the Precambrian Shield, and is covered by vegetation characteristic of the boreal forest (Upper English River – B.11 – forest region of Rowe 1972). Lakes varied in size between 5 and 5314 ha. As reported in Croskery (1990) for the study area, the number of loon territories showed the strongest correlation with shoreline length (r = 0.96). In total, 272 territories were identified on 36 of the lakes. Four lakes had no permanent resident loons.

Each lake was surveyed every 10 days during the open water season (May-September) from 1982 to 1986. Time constraints imposed by the size of the study area prohibited locating all nest sites. With the exception of the first year of the study, 20% of the territories were thoroughly searched for nests each year. Nests monitored were representative of the range of lake sizes and resident loon densities found within the study area.

Nest searches were conducted during the last week of May and the first three weeks of June in each year. This is the period of greatest nesting activity (Croskery 1989). Once located, a nest was checked at 10-day intervals until its fate was established. Young were monitored, following hatch, to eleven weeks of age.

A nest was considered successful if at least one egg hatched. Almost fully feathered at eight weeks, juvenvile loons attain flight capability at approximately eleven weeks (Barr 1973). At this time, parental care is greatly reduced and young Common Loons may be considered as fledged.

Results

Of 326 eggs deposited in the 193 study area nests (Table 1), almost 60% (191) hatched (Table 2). Most of the hatch was from two-egg nests where both (156) eggs hatched. Less than 20% (61) of all eggs were in single egg clutches and these accounted for only 10% (21) of the total hatch.

For all nests, the five-year average hatching success rate was nearly 60% (annual range 52–69%). The hatching success rate for individual eggs was similar (58%). For individual loon pairs, the

TABLE 1. Number of 1-egg and 2-egg nests and nest loss for Common Loons, Ignace, Ontario, Canada, 1982–1986.

Number of eggs	1982 Nests	1982 Lost*	1983 Nests	1983 Lost	1984 Nests	1984 Lost	1985 Nests	1985 Lost	1986 Nests	1986 Lost	Total Nests	Total Lost
1	5	4	13	10	15	7	16	12	12	7	61	40
2	14	5	32	9	30	9	26	8	300	8	132	39
Totals	19	9	45	19	45	16	42	20	42	15	193	79

*Lost = nests having nil egg(s) hatch.

mean number of eggs laid was 1.69 while hatching success rate was 0.99.

Two-thirds of all nests contained two eggs while the remainder had one-egg clutches. In all years, complete nest failures (egg loss) were substantially higher for one-egg clutches than two-egg clutches.

Since Common Loons regularly reuse previous nest sites (Strong 1985; Croskery 1990) and nest searches were initiated early in the season, most nest sites were identified prior to egg laying. Both frequency of monitoring and extensive nest area searches ensured that at single-egg nests another egg had not been present. Where evidence of a second egg was found, those nest sites were treated as two-egg nests.

For nests with two eggs (Table 3), neither egg hatched in 30% (n = 40) of these nests and only one egg hatched in 10% (n = 14). For the other 60% (n = 78) of two-egg clutches, both eggs hatched and more than half (n = 44) fledged both young.

The five-year average fledging success for nests was 47%, however, the fledging success of individual eggs was substantially lower (36%). For the eggs that hatched, 62% fledged. The fledging rate was 0.61 young nesting pair.

Discussion

From an individual nest standpoint, nearly half (47%) of all nesting attempts resulted in fledged young. This was largely the result of the high hatch-fledge success rate of two-egg clutch nests. When young were lost most were from two-chick groups but rarely did both chicks fail to fledge.

Similar results were reported from Minnesota (Valley 1987). Croskery (1988) noted that first-time nesters in new habitats only laid one egg therefore leading to the speculation that single-egg nests may be more typical of inexperienced birds.

For nests with two eggs, 70% had at least one egg hatch. When both eggs hatched, almost half of these groups fledged only one young. These data suggests that the presence of a second chick may have increased the individual vulnerability of each chick to predation and that parental care is more effective when tending only one young, conclusions shared by Yonge (1981).

Causes of egg loss were mainly nest predation and, secondarily, abandonment or drowning. Both birds and mammals were equally significant predators. When abandonment occurred, it was

TABLE 2. Number of eggs hatched and young fledged from Common Loon nests: Ignace, Ontario, 1982-1986.

	1982	1983	1984	1985	1986	Total
Nests	19	45	45	42	42	193
Successful hatch[1]	10 (53%)	25 (55%)	30 (65%)	22 (52%)	27 (69%)	114 (59%)
Successful fledge[2]	8 (42%)	18 (40%)	25 (59%)	15 (36%)	24 (57%)	90 (47%)
Total eggs	33	78	75	68	72	326
Eggs breeding pair	1.74	1.73	1.67	1.62	1.71	1.69
Total hatch	19 (58%)	46 (59%)	46 (61%)	36 (53%)	44 (61%)	191 (58%)
Hatch breeding pair	1.00	1.02	1.02	0.86	1.05	0.99
Eggs that fledge	11 (33%)	25 (32%)	31 (41%)	20 (29%)	32 (44%)	119 (36%)
Hatch that fledge	11 (58%)	25 (59%)	31 (67%)	20 (55%)	32 (73%)	119 (62%)
Fledged YOY[3]	0.58	0.56	0.69	0.48	0.76	0.61

[1]Successful hatch at least 1 egg hatched in nest
[2]Successful fledge 1 young fledged from nest
[3]YOY Young of year fledged breeding pair

TABLE 3. Outcome of 2-egg clutches for Common Loon nests Ignace, Ontario, 1982-1986.

	1982	1983	1984	1985	1986	Total
			HATCH			
Number hatched						
0	5	10	9	8	8	40
1	0	1	4	4	5	14
2	9	21	17	14	17	78
Total	14	32	30	26	30	132
			SURVIVAL WHEN 2 YOUNG			
Number fledged						
0	1	6	1	3	3	14
1	5	8	10	6	5	34
2	3	7	6	5	9	30
Total	9	21	17	14	17	78
			SURVIVAL WHEN 1 YOUNG			
Number fledged						
0	-	0	0	2	0	2
1	-	1	4	2	5	12
Total	-	1	4	4	5	14

usually at two-egg nests with the adults leaving the nest after the first-egg hatch. When drowning occurred, it was the result of an egg being dragged, or knocked off the nest, into water and not the result of fluctuating water levels.

In two-egg nests, the incidence of hatch failure for one egg was very low. When it did occur, it was usually a result of egg abandonment or drowning. Predation of one egg only in two-egg clutches did not occur. It would appear that predation, when it occurred usually resulted in the loss of all eggs contained within the nest.

Since two-thirds of all eggs hatched, but only one-third of all eggs resulted in fledged young it would appear that mortality factors act equally on both eggs and young loons. For eggs that hatched, almost two-thirds of the resultant young fledged (eleven weeks of age).

Within the study area, the primary cause of chick mortality was thought to be the loss of parental care resulting from family units being split up. Without the protection of adult birds, young were the subject of numerous avian predators including Herring Gulls, Ravens and Bald Eagles. Neither food limitations nor human-related impacts were significant mortality factors on any of the lakes in this wilderness-like study area.

Most young mortality occurred during the first two weeks of life but overall 0.61 young were fledged per breeding pair. It should be noted that this does not reflect young production by breeding pairs for the entire study area since only known nests were considered. Croskery (1990) presents a more comprehensive evaluation of young production by territorial pair and also examines the importance of individual territories to annual recruitment in the area's common loon population.

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Coyote, *Canis latrans*, Ecology in a Rural-Urban Environment

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Atkinson, K. T., and D. M. Shackleton. 1991. Coyote, *Canis latrans*, ecology in a rural-urban environment. Canadian Field-Naturalist 105(1): 49–54.

Coyotes (*Canis latrans*) have moved into and adapted to the rural-urban environment of the Lower Fraser Valley, British Columbia, relatively recently. In a study of Coyote ecology in the Lower Fraser Valley, we trapped 26 individuals and placed radio-collars on 13 of them. Mean litter size determined from placental scars, number of foeti and direct observations of females three years old and older was 5.4 ($\pm$ 1.8 S.D.). Most births occurred between late April and early May. Analysis of Coyote scats showed that voles (*Microtus* spp.) made up 70.2% of the Coyotes' diet, with the remainder composed of many different food items which were often seasonal in occurrence. Most 95%-home-ranges of radio-collared Coyotes were small (mean = 10.8 $\pm$ 11.2 km^2), and activity patterns appeared to be related to the high availability of nocturnal voles. Coyotes were most active and moved the longest distances at night, although they were also active during daylight.

Key Words: activity patterns, coyotes, food habits, home range, predation, reproduction, rural-urban.

Coyotes (*Canis latrans*) are a highly successful predator because they have both catholic food habits (Bergeron and Demers 1981; Gier 1968; Hawthorne 1972), and a flexible social organization (Althoff and Gipson 1981; Bowen 1981; Camenzind 1978; Messier and Barrette 1979), which allow them to survive in a diverse array of natural habitats throughout most of North America (Young and Jackson 1951). Recently, Coyotes have also become established in urban areas with dense human settlement, where presumably they must adapt to these new, but constantly expanding habitats.

Coyotes moved into the Lower Fraser Valley, British Columbia, in the 1930s (Young and Jackson 1951), where their subsequent increase followed habitat changes mainly resulting from deforestation. The Valley is now a patchwork of second growth forest, agricultural and natural vegetation areas, and suburban and urban developments. Native mammalian predators (Red Fox, *Vulpes vulpes;* Cougar, *Felis concolor*; Black Bear, *Ursus americanus*) are rare or absent, and though some species of natural prey are still abundant, there are also several introduced species as well as livestock. Complaints, primarily from hobby farmers, suggested that Coyotes were preying significantly on domestic livestock, especially sheep (B.C. Fish and Wildlife Branch, unpublished files).

The major purpose of our study was to investigate the ecology of Coyotes in a rural-urban environment to determine: (1) how the species has adapted to such relatively atypical habitat by comparing our findings with studies of Coyotes in their natural habitats, and (2) to evaluate the extent of Coyote predation on domestic livestock.

Study Area

The study area covered approximately 1300 km^2, of the wide, flat Lower Fraser Valley (LFV), west from Chilliwack, and bounded on the north by the Fraser River and on the south by the Canada-USA boundary. Elevations run from 15 to 300 m a.s.l., and the LFV lies in the wetter subzone of the coastal Douglas Fir Zone (Krajina 1969), characterised by Douglas Fir (*Pseudotsuga menziesii*), Western Red Cedar (*Thuja plicata*), Hemlock (*Tsuga heterophylla*), and Red Alder (*Alnus rubra*). However, much of the forest has been cleared for agriculture and urban expansion, and only isolated forested areas remain. The human population is concentrated in Vancouver and in adjacent municipalities, mainly in the western part of the study area. The composition of the study area was as follows: forest and undisturbed native vegetation: 24.2%; pasture and agricultural grasslands: 33.0; agricultural croplands (including greenhouses): 12.5%; urban core and high density housing: 17.5%; rural housing: 4.2%; recreational areas: 3.1%; highways (including meridians): 1.4%; miscellaneous: 4.1% (Canadian Wildlife Service, undated).

Methods

Reproduction

Reproductive tracts were removed from female Coyote carcasses provided by Provincial Government Wildlife Control Officers (WCO), and the number of feti or placental scars recorded. Kennelly et al.'s (1977) scale was used to estimate the date of conception. Feti too small to be aged this way were placed in the 4-week age class.

Food Habits

Permanent transects were established and cleared of scats so that fresh, dated scats could be collected monthly and frozen. Foxes were rare, and dog scats were characteristically textureless due to their commercial foods, so all scats larger than 5 mm diameter were classed as Coyotes'; doubtful specimens were discarded. Thawed scats were sterilized, washed and air dried (Bowen 1981), and then food items identified using a reference collection and published keys (Adorjan and Kolenosky 1969; Moore et al. 1974). Frequencies of food items were recorded and their percent volume was visually estimated. Data were grouped by season: *Spring* = March to May; *Summer* = June to August; *Fall* = September to November; *Winter* = December to February.

Home Ranges, Movements and Activity

Coyotes were caught using Victor #2 coil-spring traps, and tranquilized with 1.0 to 1.5 ml of a mixture (50:50) of Ketaset (ketamine hydrochloride) and Rompun (xylazine hydrochloride). All were ear-tagged and 13 were equipped with radiocollars. Radio locations were obtained either using compass bearings taken from at least three known ground locations, or from the air using a fixed-wing aircraft. Locations were used to plot home ranges by the minimum convex polygon method using the program HOME (Harested 1981). Individuals were classes as either *residents* — remained within one main activity area > 3 months; *transient — residents* — remained in a main activity area > 3 months but then moved abruptly to another area, and did not return; *transients* — never remained in any area > 3 months.

The radiocollars had tip-switches whose signals were monitored for 5 min per hour during a 24-h period, to record active-inactive states and locations. Minimum 24-h distances travelled were cumulative straightline measures between consecutive hourly locations. The 24-h period was divided into *dawn*: 1 h each side of sunrise, *day*: between dawn and dusk, *dusk*: 1 h each side of sunset, and *night*: between dusk and dawn.

Results

Reproduction

Mean (± S.D.) litter size, determined from placental scars, number of foeti and two free ranging litters over three years, was 5.4 (± 1.8, n = 20). Based on fetal measurements of 10 litters, conception took place between early January and April, with 30% in January, 50% in February, and the remainder between the end of February and early April. With a 63-day gestation, most births should have taken place between early April and early May.

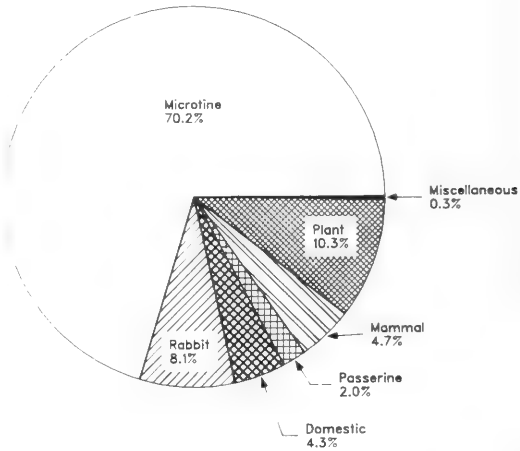

FIGURE 1. Overall diet composition (percent scat volume; n = 862) of Coyotes in the Lower Fraser Valley, British Columbia, 1980-1981. Food items labelled "Mammal" consist of identified and unidentified wild mammal species other than rabbits and small rodents. See text for species identification.

Food Habits

Small rodents (> 95% *Microtus townsendii*) were the major food item, averaging 70.2% by volume of all scats (n = 862, Figure 1), with rabbits (*Sylvilagus* spp.) the second most frequent mammalian remains in scats (8.1%). Other wild mammal remains identified in scats included Raccoon (*Procyon lotor*), Opossum (*Didelphis marsupialis*), Muskrat (*Ondatra zibethicus*), and Black-tailed Deer (*Odocoileus hemionus columbianus*).

Domestic livestock comprised only 4.3% of the Coyotes' total diet, exceeding only passerine birds and miscellaneous items (Figure 1). Remains of domestic species in scats included sheep (*Ovis aries*), cattle (*Bos taurus*) pigs (*Sus scrofa*) and chicken (*Gallus domesticus*). Domestic sheep, the major species in Coyote depredation complaints, constituted only 0.2% of scat volume.

Plant material was the second most frequent item occurring in scats. Most of the plant matter was composed of species such as plums (*Prunus* spp.), apples (*Malus* spp.), various grasses, and small quantities of holly (*Ilex* spp.) and Broom (*Cytisus scoparius*). These species were consumed as they became seasonally abundant.

Insects were often eaten, especially various species of Coleoptera, Odonata and Orthoptera. Miscellaneous items consumed included paper, cloth, plastic and rubber.

The nine identified diet items were combined into four categories for analysis: small rodents;

rabbits; fruit and grass; and "various" (birds, mammals, livestock, and miscellaneous). Significant seasonal variation in the relative proportions of these four food groups ($\chi^2 = 150.15$, df = 18; Figure 2) occurred, probably due more than anything to the highly seasonal use of fruits and seeds during summer and fall (Figure 2). Scats composed entirely of grasses were found throughout the year.

Although only a minor diet component, domestic sheep remains were found mainly in scats collected during spring and summer (Figure 2). Small rodents varied seasonally and were most frequent in the winter scats, and though all other food items also varied throughout the year they were only of minor importance (Figure 2).

Home Ranges, Movements and Activity

Twenty-six Coyotes were captured 29 times, of which 8 males and 5 females were radiocollared (Table 1). Six (2 females; 4 males) were classed as transients, three as transient-residents (1 female; 2 males), and the rest residents. We were able to monitor the movements of only one transient (M3) relatively frequently, and during 437 days it covered an area of 219.7 km². Two other transient Coyotes were lost when they moved south to Washington State, and a third radiocollared individual was killed on the north side of the Fraser River in 1984 (D. Pemble, personal communication), but was buried before we could identify it.

Coyotes were relocated and observed in all of the habitats found throughout the study area, including urban core areas. However, they were primarily located in the agricultural areas which included hobby farms, pastures and second-growth forest.

We could not test whether the mean 95% home ranges of the two sexes differed significantly, because the sample of collared females and the number of their locations were too small. When the home ranges of transient M3 (largest home range) and of resident M8 (least locations) are removed, the mean (± S.D.), male, 95% home-range size was 7.7 ± 4.2 km². Similarly, when the two females with the smallest number of locations were removed, mean, female, 95%-range size was 17.0 ± 20.7 km². With the four animals removed, overall 95%-home-range size was 10.8 ± 11.2 km².

General activity patterns were based on 29 complete, continuous 24-h monitoring sessions (19 males; 5 females) and on eight shorter periods for which one or more daily segments were complete. Coyotes were most active at night when they travelled the farthest (Kruskal Wallis H = 15.1, df = 3), moving an average (± S.D.) of 1.4 ± 1.30

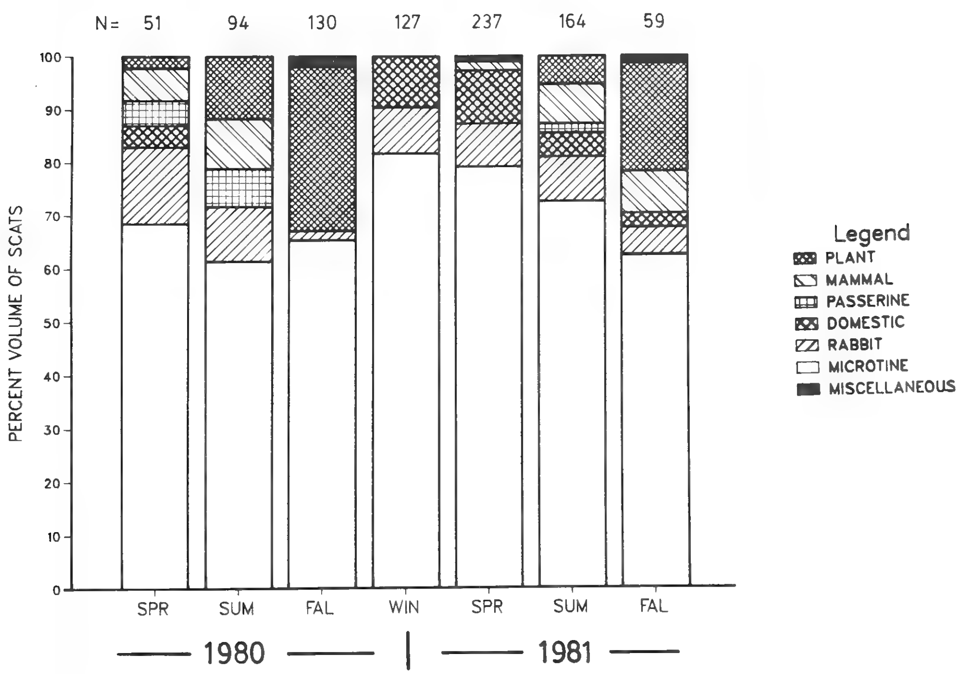

FIGURE 2. Seasonal changes in the diet of Coyotes (percent scat volume) in the lower Fraser Valley, British Columbia, 1980-1981. (SPR – spring; SUM – summer; FAL – fall; WIN – winter).

TABLE 1. Home range sizes of radio-collared male and female Coyotes in the Lower Fraser Valley, British Columbia, 1980-1981. All animals were adults (> 1 year old) except male 7.

Coyote I.D.	Period Monitored (days)	Number of Locations	95% Home Range size (ha)	Status[a]
Females				
1	41	26	8.5	T
2	396	75	6.8	R
3	160	52	40.8	R-T
4	220	53	3.4	R
5	50	23	2.7	T
Males				
1	249	87	11.5	R-T
2	184	85	11.5	R-T
3	437	68	182.4	T
4	367	91	11.1	R
5	215	60	5.5	R
6	364	58	1.6	R
7	348	80	5.1	R
8	132	20	23.3	T

[a]R = resident; T = transient; R-T = resident-transient; see text for definitions.

km (n = 24), compared to 0.6 ± 1.0 km (n = 28) during dawn, 0.7 ± 1.0 km (n = 28) during the day, and 0.3 ± 0.5 km (n = 28) around dusk. The mean distance moved by the Coyotes over 24 h was 3.3 ± 2.7 km (0.0 - 9.9 km, n = 24). There was no significant seasonal difference in daily movements (H = 3.69, df = 3), though spring and summer distances were longest; spring - 3.8 km ± 2.6, n = 6; summer - 4.8 km ± 3.6, n = 7; fall - 2.2 km ± 1.5, n = 5; winter - 2.0 km ± 1.4, n = 6).

Discussion

Reproduction

Mean litter size of LFV Coyotes was comparable to that from other parts of North America (Knowlton 1972; Nellis and Keith 1976; Todd et al. 1981), as was the temporal pattern of breeding (Gier 1968; Gipson et al. 1975; Kennelly 1978). Our use of three different techniques to estimate reproductive parameters could lead to errors (e.g. foetal reabsorption, regression of placental scars, not observing the entire litter), but the small samples precluded a more exact determination.

Food Habits

The characteristic catholic food habits of the Coyote were well illustrated by those in the LFV. Lagomorphs and small rodents form the bulk (50 to 60% by volume) of the Coyote's diet throughout its distribution (e.g., Gier 1968; Pastuck 1974; Sperry 1941; Weaver 1977), but unlike our results, lagomorphs are usually the most important food. The Eastern Cottontail Rabbit (*S. floridanus*), an introduced species in the LFV, was probably the species eaten most by LFV Coyotes, although some Mountain Cottontails (*S. nuttali*) may also have been consumed (F. Bunnell, personal communication). Unfortunately, we have no estimates of the abundance and availability of rabbits in the LFV, but small rodent biomass was probably greater and relatively more available. Taitt and Krebs (1983) found vole populations fluctuated seasonally and annually on Westham Island in the LFV, with densities over 1000 voles per ha. During our study, the mean annual density was 200 voles per ha, which is probably similar throughout the LFV (C. J. Krebs, personal communication). Except for the highly seasonal use of fruits and seeds, all food items other than rodents and rabbits were of relatively minor importance.

Although our estimates of domestic sheep in the LFV Coyotes' diet may be slightly low relative to rodents and rabbits, because of differences in the relative surface area to mass among these prey species (Floyd et al. 1978), domestic livestock were only a very minor component of the diet during our study. This finding did not support the level of Coyote predation suggested by the number of complaints received by the Fish and Wildlife Branch from hobby farmers prior to our study, but was probably partly due to the fact that approximately 80% of the complaints were made by only 14% (n = 112) of the farmers (D. Pemble personal communication), and whose animal husbandry procedures would not deter Coyote predation (Atkinson 1985).

When available, domestic livestock are usually found in Coyote diets (Bergeron and Demers 1981; Danner and Smith 1980; Gipson 1974; Sperry 1941), but it is impossible to distinguish carrion feeding from predation when diets are estimated from scat contents. Poultry remains in LFV Coyote scats were most probably carrion because the majority of poultry were intensively reared in Coyote-proof buildings. Also, several farms deliberately put out chicken carcasses for Coyotes to dispose of, and chicken manure used as fertilizer often contained chicken feet, an item found to comprise the entire contents of several Coyote stomachs examined (Atkinson 1985). By contrast, the majority of sheep remains in LFV scats probably were due to predation because most sheep carcasses were promptly and adequately disposed of through sales to rendering or petfood companies. Carcasses used for bait by WCO's for Coyote control would not contribute to our scat sample because lethal control methods were used (*but see* Pastuck 1974). Some scavenging on dead sheep buried in shallow (< 15 cm) pits was noted

together with feeding on carcasses of cattle put out deliberately for Coyotes to clean up.

The strongly seasonal use of livestock, especially sheep, by the Coyotes in the LFV could simply reflect seasonally related, frequency dependent predation on lambs which were killed twice as often as were ewes (Atkinson 1985). But, with the high densities of voles in the LFV, why would they need to prey on livestock? Kauffeld (1977) found that Coyotes used sheep as a buffer species in areas of low, natural prey biomass, whereas in our study area it may have reflected seasonal variation in the relative availabilities of lambs and voles. During spring and summer, vegetation provides excellent cover for voles and thus reduces their susceptibility to predation (Taitt and Krebs 1983), while large numbers of lambs are both available and vulnerable. In addition during these two seasons, the Coyotes incur the major costs of rearing young.

Home Ranges, Movements and Activity

Small home ranges and frequent short-term tenure were major features of the LFV Coyote studied. Average home range sizes of males (excluding M3 and M8) are the smallest reported to date (Andelt and Gipson 1979; Berg and Chesness 1978; Bowen 1982; Danner and Smith 1980), and home ranges for LFV females appear also to be small. The high densities of voles (Taitt and Krebs 1983), their major prey, probably accounts for the small home range size of LFV Coyotes.

We were unable to explain the relatively large number of transients and large scale movements observed. Dispersal is usually considered to occur if an animal leaves one home range and moves to another (Hibler 1977), but this was not found in the LFV, nor were the transient animals sub-adults. Evidence from two other studies (Althoff 1978; Laundre 1979; both cited in Laundre and Keller 1984) suggests that searching for mates could be involved in these movements.

Other variation that we observed in Coyote movements and activity may be related to their reproductive cycle (Andelt and Gipson 1979; Laundre and Keller 1981) and to seasonal and diurnal cycles in ambient temperatures (Laundre and Keller 1981). Seasonal movements were shorter in the LFV during winter and fall, which could have been related to an increase in prey availability (Todd et al. 1981). The periods of limited Coyote movements coincided with increases in vole densities, in turn related to vegetative cover die-off and winter flooding, both of which restricted voles to smaller areas (Taitt and Krebs 1983). Such an increase in the density and availability of their major food, could have reduced the Coyotes' needs for extensive movements, because as Reichel (1976) found, they probably selected such areas of high vole density.

Our findings that LFV Coyotes were most active and travelled most at night, the time when most farms lost sheep, agree with Henne's (1975 *cited in* Dorrance and Roy 1976) study. But others have found coyotes to be most active around dawn and dusk, with extensive movements in between (Andelt and Gipson 1979; Laundre and Keller 1981; Woodruff and Keller 1982). Possibly, in the LFV at least, their activity pattern was related to that of their major prey, voles, which also are primarily nocturnal (Calhoun 1945; Van Horne 1983).

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Winter Food Habits of Marten, *Martes americana*, on the Queen Charlotte Islands

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We analyzed prey remains in the digestive tracts from 97 Martens of known sex taken on the Queen Charlotte Islands during winters of 1983 to 1986. The diet was diverse consisting mostly of birds (55% frequency of occurrence), and carrion from deer (35%) and fish (27%). Small mammals (14%) and marine invertebrates (8%) were minor food items. We found nothing in the diet that would account for the distinct cranial morphology or pronounced sexual size dimorphism exhibited by this insular population.

Key Words: Marten, *Martes americana*, Queen Charlotte Islands, winter diet, cranial morphology, sexual size dimorphism.

The Queen Charlotte Islands are geographically isolated and have a depauperate mammalian fauna. Small mammal prey available to Marten (*Martes americana*) is limited to the native Deer Mouse (*Peromyscus maniculatus*), Sitka Mouse (*Peromyscus sitkensis*), and Dusky Shrew (*Sorex monticolus*) and the introduced Muskrat (*Ondatra zibethicus*), Beaver (*Castor canadensis*), Red Squirrel (*Tamiasciurus hudsonicus*), and Black Rat (*Rattus rattus*). Voles, which are a major item in the diet of Marten from continental North America (Strickland and Douglas 1987), are absent. The only other small carnivore on the Queen Charlotte Islands is the Ermine (*Mustela erminea*). Because of the limited prey base, lack of competitors, and availability of marine resources, Queen Charlotte Islands' Marten would be expected to show differences in food habits from other populations. Distinct cranial morphology and greater sexual dimorphism in skull size compared with other coastal Marten also suggest a unique feeding niche (Foster 1965; Giannico and Nagorsen 1989). Except for Foster's (1965) anecdotal observations, however, no data are available on the food habits of this insular population. A sample of carcasses obtained during the winter fur harvest provided an opportunity to determine prey items and evaluate sexual variation in diet.

Study Area and Methods

Marten were collected from five registered traplines on Graham, Moresby, and Louise islands (Figure 1). Trapsites were all at low elevations in the Coastal Western Hemlock biogeoclimatic zone (Krajina et al. 1982) in second growth forests of Western Hemlock (*Tsuga heterophylla*), Western Red Cedar (*Thuja plicata*), Yellow Cedar (*Chamaecyparis nootkatensis*), Sitka Spruce (*Picea sitchensis*), Lodgepole Pine (*Pinus contorta*), and Red Alder (*Alnus rubra*). All of these lines were near the ocean. Winter climate of the study area was characterized by heavy rainfall and sporadic snow cover (Calder and Taylor 1968).

Our study was based on 97 carcasses taken in Conibear-type traps in arboreal box sets (Baker and Dwyer 1987). Carcasses were collected during three trapping seasons (November-March) from 1983 to 1986: 12 (1983-1983), 32 (1984-1985), 53 (1985-1986). Total monthly samples were 72 in January, 2 in February, 11 in March; month of capture was unknown for 12 animals. We identified prey remains from vertebrate and invertebrate specimens in the collections of the Royal British Columbia Museum. Body parts (feet, tails, bills, bones, teeth) as well as macroscopic and microscopic features on hair fibres and feathers (Day 1966) were used to identify birds and mammals. Fish were readily distinguished from other vertebrates from bones and scales; no attempt was made to identify fish remains to species. Invertebrate material could be identified only to order or family. We classified partly digested meat and skin as unidentified digested material; undigested pieces of obviously cut meat were regarded as bait.

Contents of the entire gastrointestinal tract were used in analyses. Because of small sample sizes Marten were pooled from all trapping periods of all traplines. Relative importance of prey items was expressed by frequency of occurrence (i.e., number of occurrences in the total sample) and mean percentage volume. Rather than calculate actual volumes, we estimated mean percentage volumes

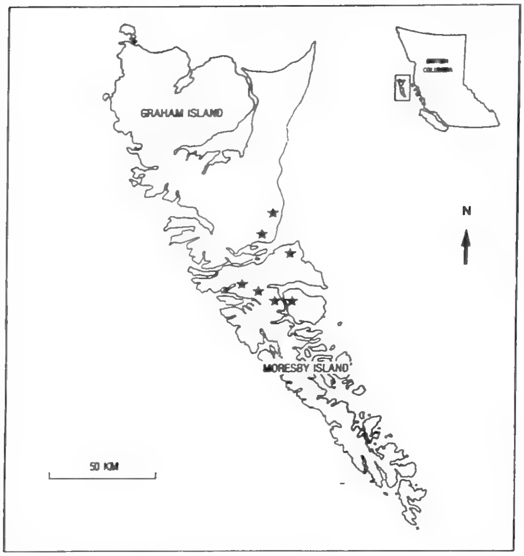

FIGURE 1. Location of study area on the Queen Charlotte Islands, British Columbia. Stars indicate trapsite locations.

by the aggregate percent method (Korschgen 1980). To evaluate sexual variation we compared the frequency of eight prey categories (Mule Deer, *Odocoileus hemionus*, small mammal, bird, fish, invertebrate, plant material, digested material, bait) in the diet of the sexes using the G-statistic. Dietary breadth and dietary overlap were calculated from the eight prey categories with the niche breadth and niche overlap formulae of Pianka (1973):

$$\text{dietary breadth} = 1/\Sigma P_i^2$$

where P_i is the proportion of food item i in the total diet. Values were standardized to range from 0 to 1 by dividing by the total number of food items (N = 8).

$$\text{dietary overlap} = \frac{\Sigma P_{ij} \cdot \Sigma P_{ik}}{(\Sigma P_{ij}^2 \cdot \Sigma P_{ik}^2)^{1/2}}$$

where P_{ij} is the proportion of food item i in the diet of group j and P_{ik} is the proportion of food item i in the diet of group k. Values range from 0 (no overlap) to 1 (identical diets).

To test for sexual variation in prey size we classified avian prey into three weight classes: 0–10 g (wrens, kinglets); 11–100 g (sapsuckers, sparrows, thrushes); and > 100 g (flickers, jays). Because of the paucity of small mammals in the diet we could not assess sexual variation in mammalian prey size.

Results

The diet was diverse with a dietary breadth index of 0.77. Excluding plant material which consisted mostly of conifer needles and moss that presumably were ingested accidentally, birds were the most important prey in frequency of occurrence and volume (Table 1). Of the identifiable birds, 54% (frequency of occurrence) were passerines and 23% woodpeckers. We identified three species of woodpeckers, Red-breasted Sapsucker (*Sphyrapicus ruber*), Hairy Woodpecker (*Picoides villosus*), and Northern Flicker (*Colaptes auratus*), but most Picidae remains were Red-breasted Sapsucker. All Troglodytidae were the Winter Wren (*Troglodytes troglodytes*) the only representative on the Queen Charlotte Islands. Other avian prey included the Golden-crowned Kinglet (*Regulus calendula*), Varied Thrush (*Ixoreus naevius*), Dark-eyed Junco (*Junco hyemalis*), Song Sparrow (*Melospiza melodia*), Pine Siskin (*Carduelis pinus*), Steller's Jay (*Cyanocitta stelleri*), Cassin's Auklet (*Ptychorampus aleuticus*), and American Coot (*Fulica americana*).

Mule Deer and fish (mostly salmonids) were also major diet items. Because deer and fish were used as bait by trappers, some of these remains may have resulted from bait consumption. Nonetheless, we suspect that most deer and fish in digestive tracts were from feeding on carrion (Nagorsen et al. 1989). Invertebrate remains were present in 28% of the Marten but mean percentage volume was less than 1%. Terrestrial invertebrates (20%) were mostly small Coleoptera; marine invertebrates (8%) included amphipods (Gammaridea), shrimp (probably Hippolytidae), and a few small crabs. Small mammals (Table 1) were a minor part of the diet. Species eaten included Red Squirrel, Muskrat, Black Rat, and *Peromyscus* sp.

Sexual variation in food habits was minimal. Of the eight prey categories only fish differed significantly among the sexes ($G = 9.059$, $P < 0.01$ occurring more frequently in males. Dietary breadth was greater for males (0.83) than females (0.68); but dietary overlap was pronounced (0.96) indicating that the sexes have nearly identical diets. We found no sexual variation in avian prey size with the three size classes of birds consumed in nearly idential proportions by males and females ($G = 0.024$, $P > 0.05$).

Discussion

Marten on the Queen Charlotte Islands have a diverse winter diet of birds, carrion (deer, salmonid fish), small mammals, and invertebrates. Nagorsen et al. (1989) described a similar diet for Vancouver Island Marten. The varied diet of Pacific coast Marten can be attributed to abundant bird and

TABLE 1. Food items in the digestive tracts of 97 Marten (*Martes americana*) from the Queen Charlotte Islands taken November-March, 1983 to 1986.

	Number of Occurrences	% Frequency	Mean % Volume
Mule Deer (*Odocoileus hemionus*)	34	35.1	10.5
Small Mammals	14	14.4	7.9
Tamiasciurus hudsonicus	5	5.2	2.0
Peromyscus spp.	4	4.1	2.1
Ondatra zibethicus	3	3.1	3.1
Rattus rattus	2	2.1	0.7
Birds	53	54.6	29.9
Unidentified Birds	18	18.6	5.0
Unidentified Passerine	4	4.1	0.6
Picidae	19	19.6	10.7
Troglodytidae	16	16.5	6.8
Emberizidae	13	13.4	2.4
Muscicapidae	8	8.2	2.0
Fringillidae	2	2.0	0.3
Corvidae	2	2.0	1.1
Alcidae	1	1.0	0.1
Rallidae	1	1.0	0.9
Fish	26	26.8	11.5
Invertebrates	27	27.8	0.5
Plant Material	72	74.2	7.8
Digested Material	58	59.8	24.2
Bait	13	13.4	7.2

marine resources. The incidence of small mammal prey in the diet of Queen Charlotte Islands' Marten is the lowest reported for any population in western North America (Table 2). Although we have no data on the abundance or availability of birds and small mammals during our study, our results and those of Nagorsen et al. (1989) suggest that in coastal forests of the Pacific Northwest small birds provide an alternate food to small mammals for Marten. The importance of birds in coastal environments should be considered in any studies of Marten foraging ecology or the effect of habitat alterations such as logging on Marten prey.

Queen Charlotte Islands' Marten are strongly differentiated from other coastal populations in cranial morphology exhibiting broad skulls, large jaws, and heavy dentition (Giannico and Nagorsen 1989). Related to feeding and mastication these morphological traits may reflect selection pressures associated with the size or hardness of

TABLE 2. Occurrence of small mammals in the winter diet of Marten (*Martes americana*) from 10 localities in western North America. Occurrence is expressed as the percentage of total food items.

Location	% Small Mammal	Number of Food Items[1]	Source
Queen Charlotte Islands, B.C.	8.9	156	This study
Vancouver Island, B.C.	27.8	727	Nagorsen et al. (1989)
Interior Alaska	71.0	107	Lensink et al. (1955)
Yukon Territory	95.2	124	Slough et al. (1989)
Fort Nelson area, B.C.	61.6	268	Quick (1955)
Rocky Mountains, Alta-B.C.	94.0	100	Cowan and Mackay (1950)
Eastern Cascades, Washington	78.8	36	Newby (1951)
North-Central Idaho	87.6	97	Koehler and Hornocker (1977)
Glacier National Park, Montana	66.0	664	Weckwerth and Hawley (1962)
Sierra Nevada, California	78.8	80	Zielinski et al. (1983)

[1]based on total number of occurrences of small mammals, ungulates, birds, fish, berries, and invertebrates.

prey. Foster (1965) hypothesized that Queen Charlotte Islands' Marten feed extensively on hard-shelled intertidal animals such as crabs. Based on our limited data however, there is nothing in the winter diet that would account for this cranial morphology. Most of the winter food consists of small birds that weigh less than 100 g and carrion. The few marine invertebrates consumed are small amphipods, shrimp, and crabs that would require minimal chewing and handling. Until a detailed study is done on food habits in all seasons, the relationship between cranial morphology and feeding ecology in this insular population remains speculative.

In a comparison of three insular and two mainland populations from Alaska and British Columbia, Giannico and Nagorsen (1989) demonstrated that the insular populations were more sexually dimorphic in cranial size with dimorphism reaching its greatest development on the Queen Charlotte Islands. Although sexual selection and energetics have been advocated as the primary cause of sexual size dimorphism in mustelids (Powell 1979; Moors 1980), selection pressures responsible for intraspecific variation in the degree of sexual dimorphism are speculative (Ralls and Harvey 1985). Giannico and Nagorsen (1989) attributed the pattern of increasing sexual size dimorphism with insularity in Pacific coast Marten to intersexual divergence in the absence of competitors. They suggested that the greater size differential on islands reduced intersexual competition for food by allowing the sexes to exploit different sized prey. Our food habits data provide no evidence for intersexual partitioning of prey resources by Queen Charlotte Islands' Marten. Nonetheless, our study was limited by small samples from one season and no information on the availability of prey. Comparative data on seasonal and year-to-year variation in diet and the availability of prey are required to evaluate dietary overlap among male and female Queen Charlotte Islands' Marten.

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Thirteenth Census of Seabird Populations in the Sanctuaries of the North Shore of the Gulf of St. Lawrence, 1982-1988

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Chapdelaine, Gilles, and Pierre Brousseau. 1991. Thirteenth census of seabird populations in the sanctuaries of the North Shore of the Gulf of St. Lawrence, 1982–1988. Canadian-Field Naturalist 105(1): 60–66.

The 1988 census revealed an increase in all families of birds present in the sanctuaries. Common Eiders increased tremendously between 1982 and 1988. The vigorous enforcement program carried out by Parks Canada in Betchouane Bird Sanctuary and by the Canadian Wildlife Service in the Îles Sainte-Marie Bird Sanctuary may explain this spectacular comeback. The high rate of yearly increase of this species supports an immigration hypothesis. Although the gull population also grew, their rate of increase was lower those that of other species. Alcids, which represent 58% of the nesting birds, continued to increase, as they have done since 1977. Two factors may account for the improvement: a better conservation program, of which enforcement and education are the two main components, and the exploitation of large predatory fish competitors by fisheries, which made more small prey fish (Capelin and sand lace) available for seabirds. However, the abundant Capelin stocks have now become attractive to the fisheries, and their imminent exploitation may augur a leaner future for the alcids.

L'inventaire de 1988 a démontré une augmentation générale de toutes les familles d'oiseaux des refuges. L'Eider à duvet a augmenté considérablement entre 1982 et 1988. L'établissement d'un système de gardiennage par le Service canadien des parcs dans le refuge de Betchouane et par le Service canadien de la faune dans les îles Sainte-Marie pourrait expliquer ce retour assez remarquable. Le haut taux d'accroissement de cette espèce laisse supposer qu'il y aurait eu de l'immigration. Les goélands ont aussi augmenté mais à un moindre rythme que les autres espèces. Les Alcidés qui représentent 58% des effectifs des refuges ont continué leur augmentation amorcée en 1977. Deux facteurs pourraient expliquer ces hausses: un meilleur programme de conservation, dont le gardiennage et l'éducation sont les deux composantes principales et l'exploitation des gros poissons prédateurs qui aurait favorisé les petits poissons (lançons et capelans), proies préférées des Alcidés. Toutefois, l'abondance du capelan est une ressource convoitée par les pêcheries et leur exploitation prochaine peut signifier un avenir incertain pour les Alcidés.

Key Words: Seabirds, population, sanctuaries, Gulf of St. Lawrence, Common Eider, larids, alcids.

In 1925, H. F. Lewis conducted the first census of migratory bird sanctuaries on the North Shore of the Gulf of St. Lawrence (Figure 1) to protect seabird colonies under the Migratory Bird Act of 1917 (Lewis 1925). A census was taken nearly every five years after that (Lewis 1931, 1937, 1942; Hewitt 1950; Tener 1951; Lemieux 1956; Moisan 1962; Moisan and Fyfe 1967; Nettleship and Lock 1973; Chapdelaine 1980; Chapdelaine and Brousseau 1984). An exceptional body of information spanning 60 years now documents the evolution of a seabird community that is typical of the waters of the subarctic, one of the oceanographic zones adopted by Nettleship and Evans (1985) to interpret the distribution of alcids in the North Atlantic. This paper presents the results of the 1988 census and compares them with those of the 1982 census.

Methods and Procedures

The survey techniques used in 1988 were basically the same as in 1982 for the most of species and sites. However, some changes were required for Common Eiders nesting in the Betchouane Bird Sanctuary and Common Murres (see Table 1 for scientific names of the birds censused) in the Iles Sainte-Marie Bird Sanctuary because of increases in these populations. All of the technical details of this census (methods, estimates, calculations, mapping of colonies, weather conditions) are discussed in Brousseau and Chapdelaine (1990) and summarized below for each family of birds.

Gaviids: We conducted a systematic count of Red-Throated Loons around the ponds on the islands in each sanctuary.

Hydrobatids: We conducted a systematic count of active burrows. A burrow was considered active if we were able to see one egg (such cases were rare), one incubating adult or signs of excavation at the entrance to a burrow giving off the oily odour characteristic of petrels.

Anatids: Methods varied depending on the sizes and numbers of islands in each sanctuary and the number of census participants. On Corossol Island, we used a system of quadrats, from which we extrapolated an average density (nests/ha) for the entire area deemed suitable for Common Eiders. In the sanctuaries where there are a great many islands (e.g., Watshishou, Île à la Brume, Baie des Loups and Saint-Augustin), we counted

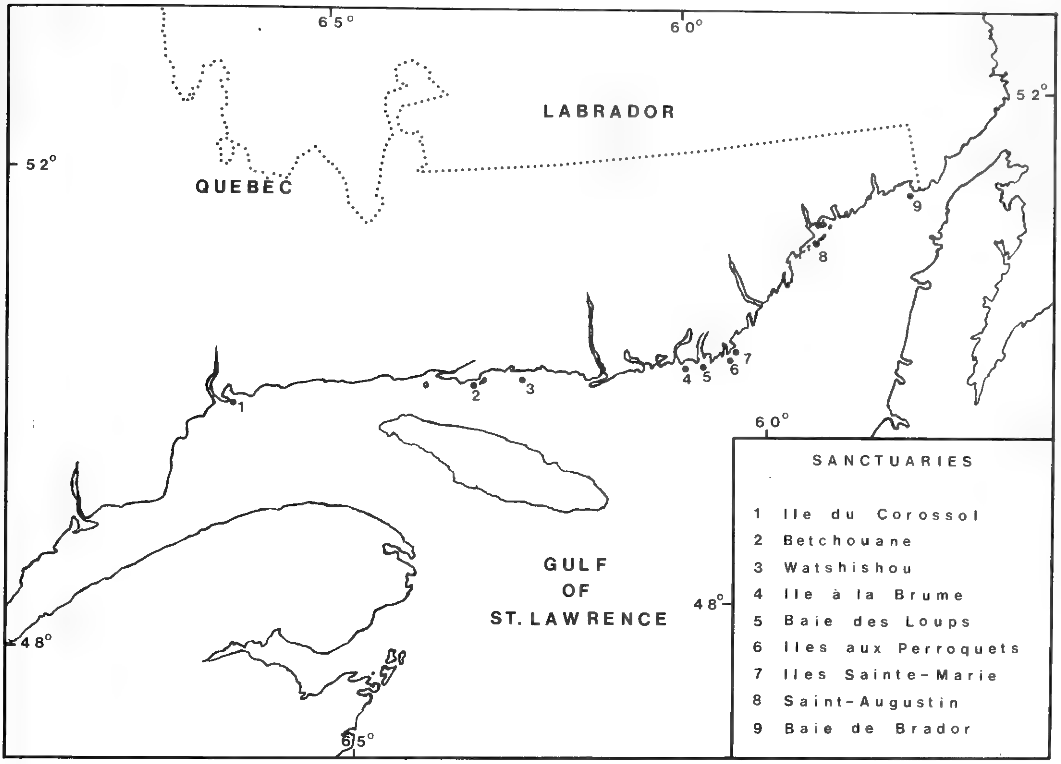

FIGURE 1. Location of the sanctuaries of the North Shore of the Gulf of St. Lawrence.

all the nests on at least 28% of the land area and extrapolated an average density over the entire area of all the islands. On Sainte-Marie and Perroquet Islands, we carried out systematic counts. In the Betchouane Bird Sanctuary, we conducted a systematic count of the nests on Calculot Island and used varying sizes of sample units (Caughley 1977) on Innu Island.

Larids: Where gull colonies numbered fewer than 100 nests, we conducted systematic counts. In large colonies where the nests were particularly scattered, we sampled sub-colonies where the number of nests (Np) and the number of adults (Ni) were determined. Then, using the factor k (k = Np/Ni), we estimated the number of pairs in the colonies where we counted only nesting individuals. These methods were applied specifically to Herring and Ring-billed gulls and to Common and Arctic terns. In the case of the Great Black-backed Gull, we counted adults nesting in the colonies.

Alcids: We conducted a systematic count of eggs in the majority of the Razorbill and Common Murre colonies. However, because of the expansion of the two Common Murre colonies on East and Cliff islands (Îles Sainte-Marie Bird Sanctuary), we counted individuals nesting in the colonies and on adjacent water from a distance to avoid any disturbance that might have caused loss of eggs. The Black Guillemot population was estimated from adult bird counts around the islands. A systematic count of active burrows was taken in the Atlantic Puffin colonies in the Betchouane Bird Sanctuary, Îles Sainte-Marie, and Îles aux Perroquet Bird Sanctuaries. On Blacklands Island, home of the vast majority of Atlantic Puffins in the Baie des Loups Bird sanctuary, we used the factor k method described above for larids. Elsewhere in the sanctuary, we conducted a systematic count of active burrows. In the Brador Bay Bird Sanctuary, we counted all occupied and unoccupied burrows using grid and line-transect procedures (Perroquet Islands). On Greenly Island, we conducted a systematic count of active burrows.

Results

The total number of birds in the eight sanctuaries increased by 46% from the 1982 census. This excludes the Saint Augustin Sanctuary, which was not surveyed in 1982. Great Cormorants and Ring-billed Gulls decreased, and all 15 other species increased or remained stable (see Table 1 for details).

TABLE 1. Census of seabirds (number of individuals) in the bird sanctuaries of the North Shore of the Gulf of St. Lawrence 1982 and 1988.

	Île du Corossol		Betchouane		Watshishou		Île à la Brume		Baie des loups		Îles aux Perroquets		Îles Sainte-Marie		Baie de Brador		Total		Saint Augustin	Grand Total
Species	1982	1988	1982	1988	1982	1988	1982	1988	1982	1988	1982	1988	1982	1988	1982	1988	1982	1988	1988	1988
Red-throated Loon *Gavia stellata*							10	6	10	6	26	20	18	44			64	76		76
Leach's Storm Petrel *Oceanodroma leucorhoa*		1474							88	208	42	6	104	56			234	1744		1744
Great Cormorant *Phalacrocorax carbo*													134	86			134	86		86
Double-crested Cormorant *Phalacrocorax auritus*	700	2938			277	282							376	1338			1353	4558		4558
Common Eider *Somateria mollissima*	246	130	30	3260	158	2074	144	608	562	846	304	362	274	1256			1718	8536	12	8548
Ring-billed Gull *Larus delawarensis*			1		24	18	178	270			188						391	288	245	533
Herring Gull *Larus argentatus*	8218	11296	908	1380	329	207	154	458	1130	672	314	660	2434	1520		2	13487	16195	6214	22409
Great Black-backed Gull *Larus marinus*	259	804	31	42	162	365	65	84	238	280	69	96	832	210	12	2	1668	1883	318	2201
Black-legged Kittiwake *Rissa tridactyla*	7334	8072	24	128								136	148	200			7506	8536		8536
Caspian Tern *Sterna caspia*							7	15									7	15		15
Common and Arctic terns *Sterna hirundo* *Sterna paradisaea*			10	39	680	890	330	295	49	4	112	34	94	88			1175	1350	632	1982
Common Murre *Uria aalge*	21	211							34	10	2710	7471	1850	18357			14615	26049		26049
Razorbill *Alca torda*	315	590	55	82	4	6	8	7	406	242	1192	2461	1216	2848	376	800	3572	7036	2	7038
Black Guillemot *Cepphus grylle*	65	151	1	15	34	15	74	26	100	53	23	96	176	178			473	521	10	531
Atlantic Puffin *Fratercula arctica*			182	226					11646	9030	2650	3494	2942	5306	13048	17086	30466	35142		35142
Total	17158	25666	1242	5159	1668	3857	970	1769	14263	11351	7630	14836	20598	31487	13434	17890	76963	112015	7433	119448

In the Corossol Island Sanctuary (visited on 4 and 5 June), we recorded major increases in Double-crested Cormorants, Great Black-backed Gulls, Common Murres and Black Guillemots. The expansion of the Cormorant colony has adversely affected the conifer forest. The impact of the invasion of this species was noted by Chapdelaine and Brousseau (1984). After several years, we noted deterioration in the trees supporting nests and an increasing number of exposed habitats now occupied by Herring and Great Black-backed gulls. There were also small colonies of Leach's Storm Petrels in sectors where the forest was in an advanced state of decline. Where the forest had been near the cliffs, we observed accelerated soil erosion which had laid the rock bare, revealing ledges and crevices now occupied by Black-legged Kittiwakes. The expansion of the Double-crested Cormorant colony has therefore helped to create habitats for other species. This is the first time that Leach's Storm Petrels have been surveyed in this sanctuary. They were first reported in 1985 (Brousseau and Chapdelaine 1987). This is the largest colony of the species reported in the Gulf of St. Lawrence thus far, but this species is often missed or poorly sampled.

In the Betchouane Bird Sanctuary (visited on 7 June), we noted a dramatic increase in the number of Common Eiders. The population has grown far beyond earlier peak counts of 1500 individuals recorded by O. H. Hewitt in 1950 and L. Lemieux in 1955. Since 1972, the species had not exceeded 100 individuals (Chapdelaine et al. 1986). We also recorded increases in Herring Gulls, Great Black-backed Gulls, Black-legged Kittiwakes, Common and Arctic terns, Razorbills, Black Guillemots and Atlantic Puffins.

Traditionally known for its Common Eiders, the Watshishou Bird Sanctuary (visited on 10 June) was in good condition. We observed significant increases in the species there. Since 1972, the numbers had varied between 296 and 158 individuals (Chapdelaine 1980; Chapdelaine and Brousseau 1984). In 1988, there were over 1000 nests in the sanctuary. We also noted increases in Great Black-backed Gulls and Common and Arctic terns. Black Guillemots and Ring-billed Gulls declined, and Double-crested Cormorants and Razorbills remained stable.

We visited the Île à la Brume Bird Sanctuary on 14 June. Common Eiders, Ring-billed Gulls, Herring Gulls, Great Black-backed Gulls, and Caspian Terns increased. Common and Arctic terns and Black Guillemots declined slightly. Except as a nesting site for a few Caspian terns, this sanctuary is of no particular interest at present. Between 1930 and 1950 it was home to about 3000 Common Murres (Lewis 1931, 1937, 1942; Hewitt 1950), but that species has not nested in the sanctuary since 1960.

The Baie des Loups Bird Sanctuary (visited on 15, 16 and 19 June) is one of the most diverse. The Atlantic Puffin is the main species there, although its numbers decreased about 23% between 1982 and 1988. We counted only 242 Razorbills, compared with populations of 8000 and more recorded between 1955 and 1965 (Lemieux 1956; Moisan 1962; Moisan and Fyfe 1967). Razorbills fell about 40% from 1982. Declines were also noted in numbers of Herring Gulls, Common and Arctic terns, and Red-throated Loons. Common Eiders and Great Black-backed Gulls increased.

The Île aux Perroquets Bird Sanctuary (visited 22 and 24 June) is frequented by 11 species. Common Murres, Atlantic Puffins, and Razorbills accounted for 90% of the birds nesting in the sanctuary. All alcid species there increased between 1982 and 1988. The Black-legged Kittiwake is a recent addition to the list of nesting species. Red-throated Loons, Leach's Storm Petrels, and Common and Arctic terns declined, however.

We visited the Îles Sainte-Marie Bird Sanctuary on 19, 20, 22, 24 and 25 June, and recorded major increases in Double-crested Cormorants, Common Eiders, Common Murres, Razorbills and Atlantic Puffins. On the other hand, there were decreases in Leach's Storm Petrels, Great Cormorants and larids in general.

Over 95% of the birds nesting in the Saint-Augustin Bird Sanctuary (visited on 29 June) are larids. As there was no census in 1982, we compared the results with the 1977 census (Chapdelaine 1980). Most striking was the virtual disappearance of Common Eiders. There were a total of 692 individuals in 1977, compared with 12 in 1988. A review of the census data since 1925 reveals that the refuge had always been favoured by this sea duck in the past. Larid numbers remained more or less at 1977 levels.

In the Brador Bay Bird Sanctuary (visited on 5 and 6 July) we observed an increase of approximately 30% in the Atlantic Puffin population. However, we observed a high mortality rate for this species in 1988 because of Arctic Foxes (*Alopex lagopus*) on both Perroquet and Greenly Islands. We counted approximately 100 carcasses of adults which had fallen prey to the foxes. Because the predators remained on the island all summer, there is reason to fear that productivity will fall for the 1988 season, and we expect population growth in the sanctuary to slow, barring unforeseen immigration. Razorbill numbers increased from 1982. We did not find any Razorbills killed by foxes, but very few eggs of this

TABLE 2. Changes in the number of seabirds in sanctuaries on the North Shore of the Gulf of St. Lawrence, Québec, 1977 to 1988.

	Year of survey			Compound annual growth* rate by period	
Species	1977	1982	1988	1977-82	1982-88
Red-throated Loon	72	68	76	-1.18%	1.87%
Leach's Storm Petrel		234	1 744		39.76%
Great Cormorant	214	134	86	-8.9%	-7.12%
Double-crested Cormorant	472	1 353	4 558	23.4%	22.44%
Common Eider	2 965	2 410	8 536	-4.1%	23.46%
Great Black-backed Gull	1 413	1 722	2 201	4.0%	4.18%
Herring Gull	11 358	18 843	22 409	10.7%	2.93%
Ring-billed Gull	1 716	945	288	-11.2%	-17.97%
Black-legged Kittiwake	3 256	7 506	8 536	18.2%	2.17%
Caspian Tern	3	7	15	18.5%	13.54%
Common and Arctic terns	1 470	1 935	1 982	5.7%	0.40%
Common Murre	10 165	14 615	26 049	7.5%	10.11%
Razorbill	3 597	3 572	7 036	-0.1%	11.96%
Black Guillemot	514	484	521	-1.2%	1.24%
Atlantic Puffin	15 223	30 466	35 142	14.9%	2.41%

$$*r = \frac{\log_e N(t) - \log_e N(o)}{t} \, 100\%$$

species were seen. Its reproduction capacity seems to have been lowered this year probably owing to the presence of foxes.

Discussion

Our results indicated a general increase in numbers of seabirds in the sanctuaries on the North Shore of the Gulf of St. Lawrence. The compounded annual rate of increase for some species was particularly high (Table 2), suggesting that immigration was partly responsible. The Common Eider is an obvious case. Using parameters for hatching success and survival of sub-adults and adults quoted by Reed and Erskine (1986), we can determine the annual growth rate on an imaginary population of 1000 Common Eider pairs. They will lay an average of 4000 eggs and raise 600 individuals to the fledgling stage (0.6/pair). Of these juveniles, 65%, or 390, reach the age of one year. Of this number, or 312, will reach reproductive maturity, at the age of 2 years. If the adult survival rate is 85%, 0.30 bird per pair (2 × 0.15) will die each year. The number of birds required to make up for this loss is 300 (0.30 × 1000). If only 312 birds are produced under average conditions there will be a surplus of only 12 birds, or 6 pairs. Taking a very optimistic view, one could hope for an annual growth rate of 0.6%, much less than the combined rates observed for all sanctuaries.

The reason for these increases are particularly difficult to determine because there are so few specific studies on the annual reproductive conditions and productivity levels which prevailed in these colonies between 1982 and 1988. Nonetheless, we feel that the general growth trend may be associated with the vigorous conservation measures adopted in a number of sanctuaries. Since 1983, the Betchouane and Watshishou sanctuaries have been included within the limits of Mingan National Park, which is managed by the Canadian Parks Service. A team of wardens regularly patrols these sectors, which have not received so much attention since the sanctuaries were created in 1925. The Canadian Wildlife Service has concentrated nearly all its wardens on the Îles Sainte-Marie Bird Sanctuary for the last five years, and moved the wardens from the Saint-Augustin Bird Sanctuary to Bradore Bay. It is probably no coincidence that the population of Common Eiders in the Saint-Augustin Bird Sanctuary has since declined.

Alcids, which account for 58% of the birds in the sanctuaries, have definitely benefited from the surveillance program. Chapdelaine and Brousseau (1989) recorded a significant increase in Black-legged Kittiwakes in the Gulf of St. Lawrence between 1974 and 1985, noting that the species benefited from an abundance of small fish such as sandlance (*Ammodytes* sp.) and Capelin (*Mallotus villosus*). These fish are thought to have increased as a result of intensive harvesting of large predators such as Cod (*Gadus morhua*) (Québec Bureau of Statistics 1977-1987). Sandlance and Capelin are the staple foods not only of Kittiwakes and other larids but also of alcids, especially while they are raising young (Bradstreet and Brown 1985). Abundant food may have positive effects on

productivity. The only species for which we could measure reproductive performance was the Razorbill, whose net productivity in the colonies on the Sainte-Marie and Perroquet Islands stood at 74% in 1988 (Chapdelaine et al., unpublished), compared with 61% in 1978 (Chapdelaine and Laporte 1982). Note that in 1978, the population of this species was at a very low level and no growth trend was indicated. But, with so little data on reproductive and feeding for alcids available between 1982 to 1988, the link and abundance of prey and a positive effect on alcid numbers remains conjectural.

The 1988 census appears encouraging with respect to the future of seabird populations on the North Shore, with a definite improvement in surveillance and a decrease in poaching (Blanchard 1984). However, commercial fishing practices may eventually have as serious an effect on present populations as poaching had in the past. The idea of a commercial fishery to harvest Capelin on the North Shore is gaining popularity. In 1988, licences were issued on an experimental basis (D. Tremblay, Fisheries and Oceans Canada, personal communication). The long term effects of harvesting on these fish, which represent a primary link in the food chain of specialized seabirds such as alcids, may be catastrophic. A number of situations already described the interaction of fisheries with seabird populations (Anderson et al. 1980; Lid 1981; Furness 1982; Burger and Cooper 1984; Duffy and Siegfried 1987), and in all cases changes in the structure of communities and considerable declines in species which specialize in commercially desirable fish species were noted.

We believe that there is an urgent need to review the concept of follow-up censuses as practised for the past 60 years on the North Shore in the light of fishing activities which may interact with seabirds. Not only must follow-up censuses be conducted, but adult survival, productivity, chick growth, nesting patterns of birds in colonies and activity time budgets must also be monitored, as these are all measurable parameters which may be related to temporary food abundance or scarcity in the marine environment (Cairns 1987) and provide an indication of the availability of prey exploited by fisheries.

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Engelmann's Quillwort, *Isoetes engelmannii*, an Addition to the Aquatic Flora of Canada

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Britton, D. M., P. M. Catling, J. Norris, and S. Varga. 1991. Engelmann's Quillwort, *Isoetes engelmannii*, an addition to the aquatic flora of Canada. Canadian Field-Naturalist 105(1): 67–70.

Isoetes engelmannii, Engelmann's Quillwort, is reported for the first time in Canada from Big Chute, Muskoka District, and West Guilford in Haliburton County, both in Ontario. The general region where these discoveries were made is one that is well known for its high floristic diversity and concentration of rare plants including species mainly found in New England and along the Atlantic coastal plain of the United States. At both Ontario locations, *Isoetes engelmannii* occurred with *I.* × *eatonii, I. echinospora, Najas flexilis, Potamogeton richardsonii* and *Vallisneria americana.* The occurrence of *I. engelmannii* in the Georgian Bay region of Ontario, and especially at Big Chute, supports the concept of the hybrid origin of *I.* × *eatonii*, which is confined to regions where *I. echinospora* and *I. engelmannii* overlap.

Key Words: *Isoetes engelmannii,* Engelmann's Quillwort, aquatic macrophyte, Isoetaceae, phytogeography, new record, Canada, ecology, systematics.

During an early September census of *Isoetes* × *eatonii* Dodge (Eaton's Quillwort) above Big Chute on the Trent-Severn Waterway, many hundreds of smaller *Isoetes* plants were observed and 40 were collected to determine their identity. Most were either lacking spores and consequently unidentifiable, or were *I. echinospora* Dur. (Spiny-spored Quillwort), but several were clearly referrable to *I. engelmannii* A. Br. (Engelmann's Quillwort), a species not previously recorded in Canada. Plants of *I. engelmannii* were also discovered along Gull River at West Guilford in Haliburton County. Since *I. engelmannii* is new to the Canadian flora and of interest as a rare native species, we briefly discuss ecological, phytogeographic and other aspects of its occurrence in Canada.

Voucher Material:

ONTARIO: *Muskoka District:* in Severn River above the dam at Big Chute and within ¼ mile of the dam, 6 Sept. 1988, *P. M. Catling, J. Norris* and *S. Varga s.n.* (OAC). *Haliburton County:* with *Potamogeton richardsonii* in water 10 cm deep along the stream running from Pine Lake to Green Lake, on the west side of West Guilford at approx. 45°06.5′N, 78°37′W and Map 31E/2, UTM 886977, 8 September 1988, *P. M. Catling* and *V. R. Catling s.n.* (DAO); in water 3 dm deep with *Najas flexilis, Sagittaria graminea*, Gull River at the Picnic area on W side of West Guilford, 45°06′30″N, 78°36′20″W, Map 31E/2, UTM 887977, 13 Sept. 1989, *P. M. Catling 10036, 10040* and *J. Norris* (DAO).

Phytogeography

Isoetes engelmannii is primarily a species of the eastern United States extending from southern Maine southwest to southeastern Missouri and south to Alabama and northern Florida (Figure 1 and Taylor et al. 1985). It has recently been collected by *Reznicek et al.* (MICH) from Allegan Co., Michigan. It is apparently disjunct in the Georgian Bay region of Ontario (Figure 2), the nearest station being in the Finger Lakes of New York State 270 km distant. This is not an unusual distribution pattern. Many other species of eastern North America and especially the Atlantic coastal plain and New England, are more or less confined in Ontario to a limited area east of Georgian Bay. Some of the most striking examples include *Bartonia paniculata* (Michx.) Muhl. ssp. *paniculata* (Reznicek and Whiting 1976), *Rhexia virginica* L. (Sharp and Keddy 1983), *Xyris difformis* Chapman (Randall and Keddy 1983), *Dichanthelium spretum* (Shultes) Freckman (Reznicek 1984b), *Panicum rigidulum* Nees var. *rigidulum* (Reznicek 1984a), *Potamogeton bicupulatus* Fern. (Reznicek and Bobbette 1976), *Linum striatum* Walt. (Dugal 1984) and probably *Triadenum virginicum* (L.) Raf. (Reznicek 1985). Plants of wet or periodically wet habitats clearly dominate the group demonstrating this phytogeographic pattern, to which another aquatic of neutral to alkaline water can now be added.

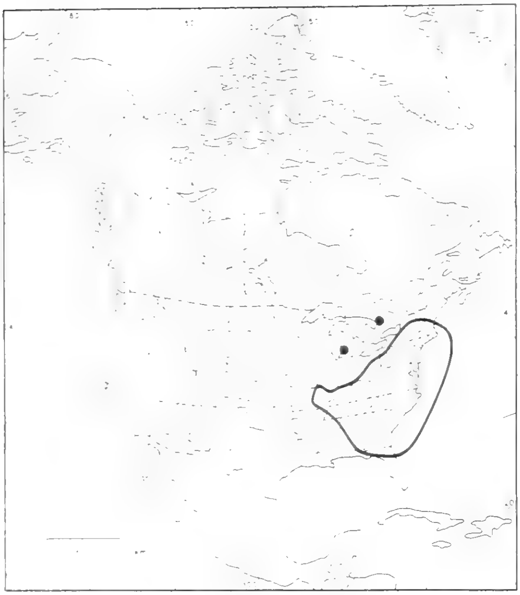

FIGURE 1. Distribution of *Isoetes engelmannii* in North America after Taylor et al. (1985) with the disjunct Georgian Bay locations and Michigan locality included.

Ecology

At both sites *I. engelmannii* was rooted in a fine sandy or silty substrate. Also at both sites, *Isoetes echinospora, Isoetes* × *eatonii, Eleocharis acicularis, Najas flexilis, Sagittaria graminea, Vallisneria americana* and small plants of *Potamogeton richardsonii* were growing nearby. At Big Chute additional associated species in approximate order of importance included *Potamogeton gramineus, Sagittaria rigida, Elodea canadensis, Potamogeton spirillus* and *Ranunculus flammula.*

At Big Chute the conductivity of water near the dam and near Pretty River Channel was 259 to 260 μohms/cm and the pH ranged from 8.0 to 8.1. At the West Guilford site the conductivity of Gull River water was 49 to 53 μohms/cm and both the rooting medium and the water had a pH range of 6.0 to 6.1.

While fluctuating water levels are clearly essential to the survival of some of the coastal plain flora in the Georgian Bay region (Keddy and Reznicek 1982), the relationship between *I. engelmannii* and amount and perodicity of fluctuation in water levels is not yet clear.

At Big Chute, the water level has fluctuated very little since 1917. A stable water level is important for navigation and hydroelectric generation, and is maintained by dams at Pretty Channel and Big Chute and also by an Ontario Hydro generating station. Prior to 1917, the level was two feet (0.61 m) lower and fluctuated much more through natural causes and because of development for the logging industry. The only recent fluctuations have involved periodic drawdowns at intervals of several years, to facilitate repairs.

The Gull River at West Guilford is subject to naturally fluctuating levels and was probably near, but not at, its lowest level, with some of the *Isoetes* × *eatonii* plants growing as terrestrials on wet silt with *Leersia oryzoides* and *Carex rostrata.*

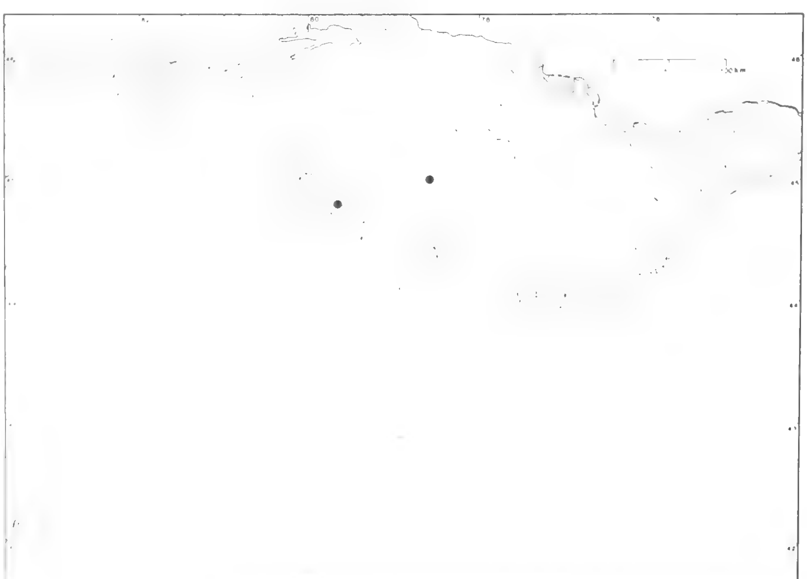

FIGURE 2. Distribution of *Isoetes engelmannii* in Ontario.

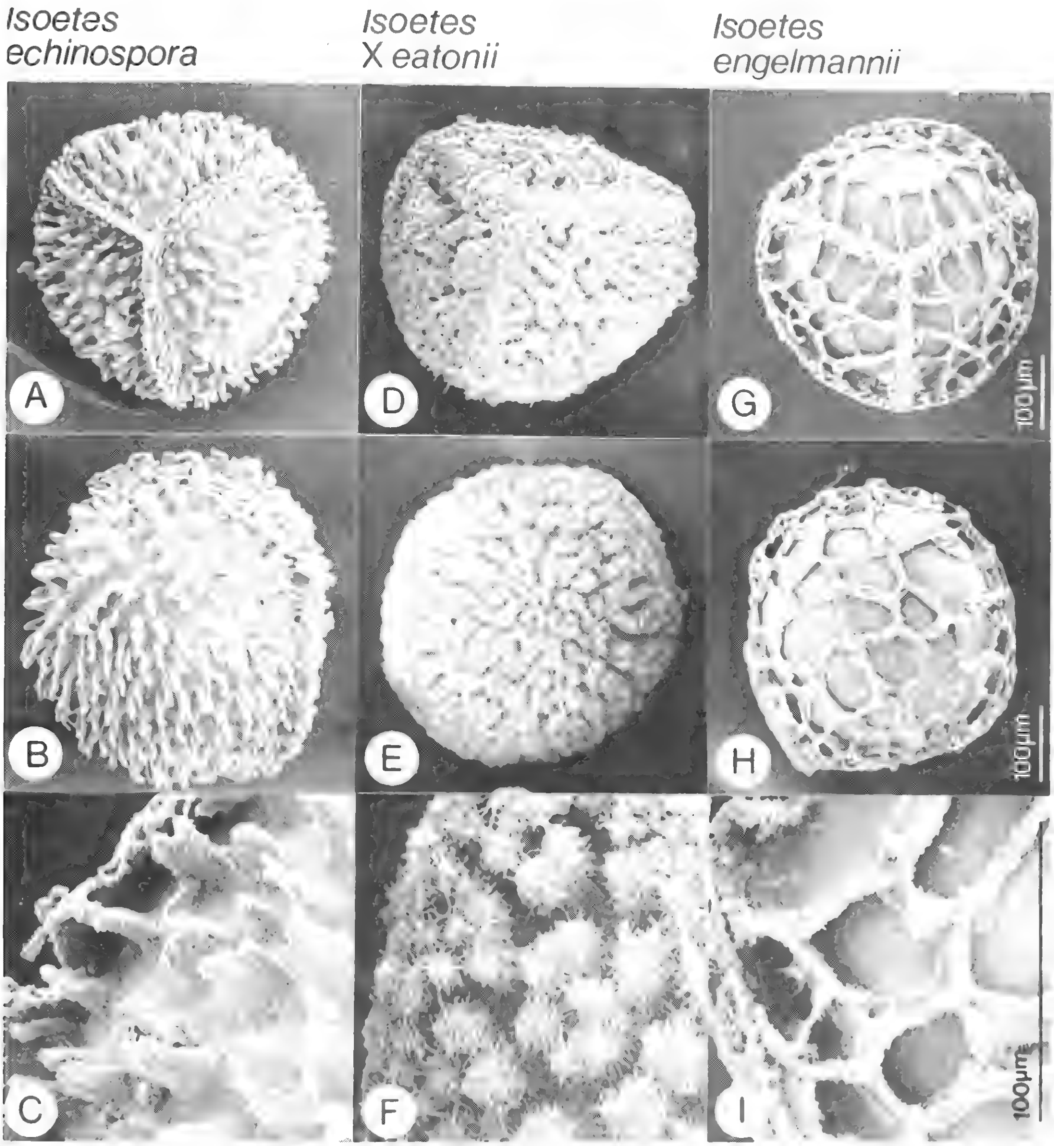

FIGURE 3. Megaspore surfaces of *Isoetes engelmannii, I.* × *eatonii* and *I. echinospora.* All photographs are of material collected at Big Chute, Muskoka District, Ontario.

Despite the fact that *I. engelmannii* was not found previously at Big Chute, an area that has received substantial attention from field botanists, there is no reason to suspect that it was recently introduced. Like *I.* × *eatonii* it is probably a long established native taxon. *Isoetes engelmannii* was overlooked at Big Chute possibly because it is much less vigorous than *I.* × *eatonii*, and because it is often practically indistinguishable from *I. echinospora* without the aid of a hand lens to examine the megaspores, and because it is apparently rare at this site.

Identification and Hybridization

The reticulate pattern of thin, sharp-edged ridges on the megaspores is a fully distinctive feature of *Isoetes engelmannii* (Kott and Britton 1983), that readily separates it from *I. echinospora* and *I.* × *eatonii* (Figure 3), the two *Isoetes* taxa which share its habitat in Ontario.

These three taxa have small megaspores because they are diploids with 2n = 22 (Kott and Britton 1983). Mean megaspore diameters given by Kott and Britton (1983) are 421, 407 and 480 for *I.*

engelmannii, *I.* × *eatonii* and *I. echinospora* respectively. Interestingly, the area of the Trent-Severn waterway above Big Chute and West Guilford are the only locations in Ontario for *Isoetes* × *eatonii* (Kott and Bobbette 1980, DAO). The fact that *I. engelmannii* has not been found at Big Chute represented an inconsistency in the well tested hypothesis of a hybrid origin of *I.* × *eatonii* which is partly based on its having a restricted distribution confined to the region of overlap in the geographic distributions of the putative parents, *I. echinospora* and *I. engelmannii*. Now that *I. engelmannii* and *I. echinospora* are known in Ontario from the same two bodies of water where *I.* × *eatonii* occurs, the phytogeographic evidence for a hybrid origin of *I.* × *eatonii* appears to be complete.

Conservation

The area at Big Chute where *I. engelmannii* occurs is a site of unusually high aquatic macrophyte diversity and is recognized as part of the Big Chute Rocklands Area of Natural and Scientific Interest by the Ontario Ministry of Natural Resources (Varga 1988). The Canadian Parks Service assumes some responsibility for protecting the site as it is a part of the Trent-Severn Heritage Canal. Proposed increases in recreational use resulting in increased physical disturbance, increased nutrient loading and development of shorelines may become threats to the survival of this species at this location. The station at West Guilford is in a stream beside a local picnic area, and is not currently recognized as significant or afforded any special protection. There are no obvious threats to its survival there at the present time.

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Habitat du Sumac à vernis, *Rhus vernix*, à sa limite nord de distribution (Haut-Saint-Laurent, Québec)

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Lavoie, Claude, Martin Jean, et André Bouchard. 1991. Habitat du Sumac à vernis, *Rhus vernix*, à sa limite nord de distribution (Haut-Saint-Laurent, Québec). Canadian Field-Naturalist 105(1): 71–77.

Le *Rhus vernix* L., une espèce rare au Québec, a fait l'objet d'un échantillonnage visant à déterminer l'influence de l'ouverture du couvert végétal et du niveau de la nappe phréatique sur son abondance et sur sa structure de population. Les données proviennent de trois populations, deux de marécages et une de tourbière, de l'extrême sud-ouest du Québec. Des tests de comparaison de Kolmogorov-Smirnov ont permis de dégager que les populations de *Rhus vernix* colonisant des érablières à *Acer rubrum* diffèrent de façon significative des populations de la même espèce colonisant des aulnaies à *Alnus rugosa.* La différence se situe principalement au niveau des semis de l'année, beaucoup moins nombreux dans les aulnaies que dans les érablières. Le *Rhus vernix* semble mal résister à la compétition pour la lumière et pour l'espace que lui occasionne *Alnus rugosa.* Il semble également que le maintien de la nappe phréatique au-dessus de la surface du sol pendant au moins une certaine période de l'année favorise le *Rhus vernix*, à condition qu'il ne soit pas dans une aulnaie. Il est possible que la rareté de l'espèce au Québec s'explique par la faible superficie du territoire de la province couvert par des érablières à *Acer rubrum* sur sol organique.

Mots-clés: Sumac à vernis, *Rhus vernix*, Haut-Saint-Laurent, *Alnus rugosa, Acer rubrum*, plante rare.

The influence of canopy opening and water table on the abundance and population structure of *Rhus vernix* L., a rare species in Québec, has been studied for three populations, two from swamps and one from peatland of extreme southwestern Québec. Kolmogorov-Smirnov comparison tests showed that *Rhus vernix* populations colonizing *Acer rubrum* forests differ significantly from those colonizing shrublands dominated by *Alnus rugosa.* A difference is apparent in the seedlings of the year, far fewer in the alder shrublands than in the maple forests. *Rhus vernix* appears to have poor resistance to *Alnus rugosa* competition for light and space. It seems also that the maintenance of the water table above the surface for at least a part of the year favours *Rhus vernix*, unless it is in alder shrubland. The rare status of this species in Québec may be explained by limited area of the province covered by *Acer rubrum* forests on organic soil.

Key Words: Poison Sumac, *Rhus vernix*, Haut-Saint-Laurent, *Alnus rugosa, Acer rubrum*, rare plant.

Comme la plupart des provinces et territoires canadiens, le Québec possède une liste de plantes vasculaires rares (Bouchard et al. 1983). Il importe à présent de mieux cerner les paramètres de la survie des espèces rares peu connues (Brouillet 1985), tel le Sumac à vernis, *Rhus vernix* L., afin d'en assurer la protection. Cette espèce se retrouve en effet à l'intérieur de marécages et de tourbières, habitats de plus en plus menacés dans le sud-ouest du Québec (Couillard et Grondin 1986; Bouchard et al. 1985). Dans cette optique, nous avons voulu vérifier dans quel habitat précis le *Rhus vernix* se maintient avec le plus de facilité en étudiant la structure de population de cette espèce dans trois milieux de la région du Haut-Saint-Laurent.

La répartition du *Rhus vernix* en Amérique du Nord coïncide sensiblement avec celle de la grande forêt décidue de l'Amérique orientale; elle excède toutefois quelque peu cette formation vers le sud (Rousseau 1974). On le retrouve du Minnesota, du sud de l'Ontario, du sud-ouest du Québec et de la Nouvelle-Écosse jusqu'au Texas et en Floride (Hill 1989; Scoggan 1978-1979). L'espèce est rare au Québec (Bouchard et al. 1983) et en Ohio (Division of Natural Areas and Preserves 1982).

Au Québec, le *Rhus vernix* est à la limite nord de son aire (Rousseau 1974). On le retrouve dans l'Outaouais, dans la région montréalaise de la plaine du Saint-Laurent et dans le Richelieu (Bouchard et al. 1983). Cette plante aurait atteint la province pendant la période algonquine à la fois par le système des Grands Lacs-rivière des Outaouais et par le système Hudson-lac Champlain (Raymond 1950).

Dans le Haut-Saint-Laurent, on compte six stations de *Rhus vernix* (Figure 1) : deux dans la Réserve nationale de la faune (RNF) du lac Saint-François (De Repentigny 1976), une dans la tourbière Large Teafield (Jean et Bouchard 1987), une dans la tourbière de Saint-Pierre (Lavoie 1984) et une dans la tourbière de Saint-Chrysostome (Raymond 1971). Lavoie (1984) n'a cependant

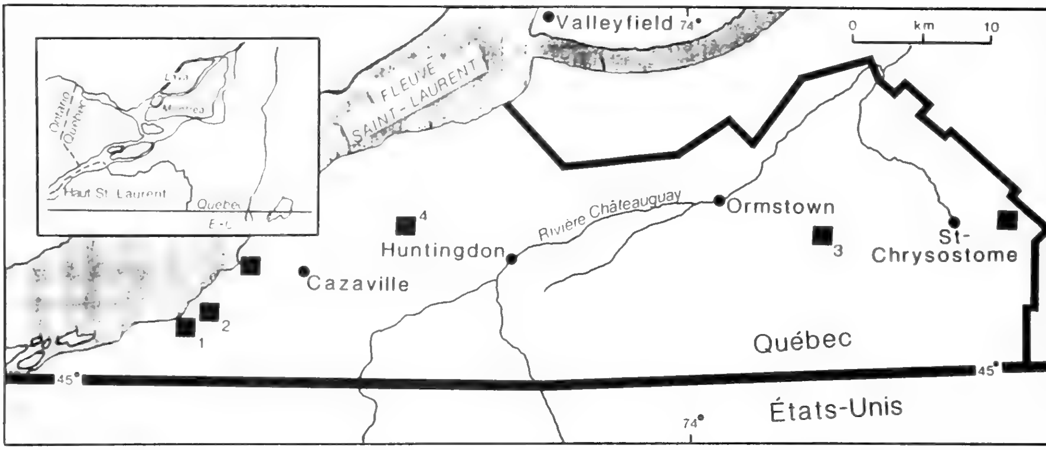

FIGURE 1. Localisation des stations de *Rhus vernix* (□) dans la municipalité régionale de comté du Haut-Saint-Laurent. Les chiffres réfèrent aux stations mentionnées dans l'échantillonnage : 1, érablière à *Acer rubrum* et 2, aulnaie à *Alnus rugosa* et *Acer rubrum* de la Réserve nationale de la faune du lac Saint-François; 3, érablière à *Acer rubrum* et *Betula populifolia* de la tourbière de Saint-Pierre et 4, érablière à *Acer rubrum* de la tourbière Large Teafield.

retrouvé aucune trace de cette dernière station. Nous avons découvert une nouvelle station, à trois km au nord-est de la RNF du lac Saint-François, dans un petit marécage à *Alnus rugosa* et *Acer rubrum*. Nous n'y avons trouvé qu'un seul individu de *Rhus vernix*. Il existe également une autre station, sur la rive nord du lac Saint-François (fleuve Saint-Laurent), en Ontario, près de Summerstown (Dore 1962).

Malgré quelques études mentionnant la présence du *Rhus vernix*, il existe peu de données sur l'écologie et les caractéristiques de l'habitat de cet arbuste. On le retrouve surtout dans les marécages comme les érablières à *Acer rubrum* (Andreas et Host 1983; Cléonique-Joseph 1936; De Repentigny et Fragnier 1986; Grondin et al. 1984; Jean et Bouchard 1987; Lavoie 1984), les mélèzins à *Larix laricina* (Lindeman 1941; De Repentigny et Fragnier 1986; Sheviak et Haney 1973) et les aulnaies à *Alnus rugosa* (Buell et al. 1968; De Repentigny et Fragnier 1986). En Illinois, il existe même des communautés où le *Rhus vernix* est l'espèce dominante (*Rhus vernix parkland*, Sheviak et Haney 1973). En ce qui concerne les caractéristiques abiotiques de l'habitat, on note que la nappe phréatique est toujours située près de la surface (Jean et Bouchard 1987) ou au-dessus, du moins pendant une partie de l'année (Andreas et Host 1983; De Repentigny et Fragnier 1986). Le couvert végétal peut être ouvert (Cléonique-Joseph 1936) ou fermé (De Repentigny et Fragnier 1986; Lindsey 1931; Sheviak et Haney 1973). À notre connaissance, aucune étude n'a été publiée relativement à la structure de population du *Rhus vernix* à l'intérieur des habitats précédemment mentionnés.

Milieux étudiés

L'échantillonnage a été effectué dans trois localités de la municipalité régionale de comté (MRC) du Haut-Saint-Laurent, à environ 70 km au sud-ouest de Montréal. Ces localités sont la RNF du lac Saint-François, la tourbière Large Teafield et la tourbière de Saint-Pierre.

Sur le plan climatique, les données de la station météorologique de Huntingdon (située au centre de la MRC du Haut-Saint-Laurent, figure 1) indiquent une température annuelle moyenne de 6,1 °C. Janvier est le mois le plus froid (-10,0 °C) et juillet le plus chaud (20,7 °C). Les précipitations annuelles moyennes sont de 961 mm; les chutes de neige atteignent en moyenne 248 mm par année et s'étalent principalement de novembre à mars. Le nombre moyen de jours sans gel est de 199 par an (Environnement Canada 1982a) et le nombre de degrés-jours (> 5,0 °C) dépasse 2093 annuellement (Environnement Canada 1982b).

Les milieux étudiés sont compris dans les basses-terres du Saint-Laurent. La RNF du lac Saint-François est située à 50 km en amont de Valleyfield (45°02'N, 74°29'O). Outre quelques boisés et milieux ouverts en situation sèche, elle comprend surtout des marécages à *Acer rubrum*, *Larix laricina* et *Alnus rugosa* (De Repentigny et Fragnier 1986) et des marais à *Carex aquatilis*, *C. lacustris*, *Typha angustifolia*, *T. latifolia* et *Calamagrostis canadensis* (Melançon et Lethiecq 1981).

La tourbière de Saint-Pierre est située à environ 25 km au sud est de Valleyfield (45°06'N, 75°52'O). Il s'agit d'une mosaïque d'affleurements et de cuvettes entourbées, où les roches sont composées

de plusieurs variétés de grès orthoquartzitique (Clark 1966). Ce type de roche confère aux sols du secteur un caractère très acide (A. Meilleur, données non publiés). Au sein des cuvettes entourbées, on y retrouve principalement des prairies à *Carex oligosperma*, et des arbustaies à *Betula populifolia* et à *Chamaedaphne calyculata* (Lavoie 1984). Une portion du territoire est protégée (Réserve écologique du Pin-Rigide). Le secteur sud-ouest de la tourbière est en partie sous culture. On y trouve aussi une forêt d'*Acer rubrum* qui repose sur un dépôt de tourbe peu épais (Grondin et al. 1984, Lavoie 1984).

Finalement, la tourbière Large Teafield se situe à environ 15 km au sud-ouest de Valleyfield (45°07′N, 74°15′O). Il s'agit d'une tourbière ombrotrophe (bog) entourée de bordures boisées minérotrophes. Elle est constituée principalement d'arbustaies basses à *Chamaedaphne calyculata,* à *Betula populifolia* et *Eriophorum vaginatum*, et à *Cornus stolonifera*, de brûlis à *Betula populifolia* et *Epilobium angustifolium*, et d'une érablière à *Acer rubrum* (Jean et Bouchard 1987).

Les quatre stations d'échantillonnage sont les suivantes: érablière à *Acer rubrum* (figure 1, station 1) de la RNF du lac Saint-François, érablière à *Acer rubrum* et *Betula populifolia* de la tourbière de Saint-Pierre (figure 1, station 3), aulnaie à *Alnus rugosa* et *Acer rubrum* (figure 1, station 2) de la RNF du lac Saint-François et érablière à *Acer rubrum* de la tourbière Large Teafield (figure 1, station 4).

Méthodologie

Échantillonnage

Les travaux sur le terrain ont été effectués en juin et en juillet 1987. A l'intérieur de chaque station décrite ci-haut, exception faite de la tourbière Large Teafield où la densité trop faible de *Rhus vernix* ne nous permettait pas d'effectuer ce genre d'échantillonnage, les populations de *Rhus vernix* ont été étudiées à l'aide d'un quadrat de 25 × 25 m subdivisé en 25 quadrats de 5 × 5 m. Un autre quadrat de 10 × 20 m a été utilisé pour déterminer les caractéristiques abiotiques du milieu et faire une évaluation semi-quantitative des plantes vasculaires présentes.

Dans chacun des 25 petits quadrats, chaque individu de *Rhus vernix* fut recensé et cartographié. Il fut aussi évalué selon l'échelle de taille semi-quantitative suivante : 1, 0–0,5 m; 2, 0,5–1,0 m; 3, 1,0–1,5 m; 4, 1,5–2,0 m; 5, 2,0–2,5 m; 6, 2,5–3,0 m; 7, 3,0–3,5 m; 8, 3,5a–4,0 m. Nous avons noté le recouvrement de toutes les espèces vasculaires également au moyen d'une échelle semi-quantitative : 1, 0–1 %; 2, 1–5 %; 3, 5–10 %; 4, 10–25 %; 5, 25–50 %; 6, 50–75 %; 7, 75–100 %. Nous avons aussi pris en considération la présence de fleurs ou de fruits sur les individus. Les mêmes informations ont été recueillies sur les individus de la tourbière Large Teafield, mais à l'intérieur d'un quadrat de 60 × 70 m (dimension minimale pour qu'il y ait au moins une dizaine de plants recensés). La nomenclature taxonomique des plantes vasculaires suit celle de Scoggan (1978-1979). Les termes utilisés pour la classification des terres humides sont ceux suggérés par le Groupe de travail national sur les terres humides (1988).

Exception faite de la tourbière Large Teafield où les données de Jean et Bouchard (1987) seront utilisées, un échantillon de sol prélevé à une profondeur de 25 cm a été recueilli à l'intérieur de chacune des stations. Les échantillons ont été séchés à l'aide d'un ventilateur, puis tamisés à 2 mm. Le pH a été déterminé au $CaCl_2$ 0,01 M, le carbone organique par perte à la calcination et l'azote total (incluant les nitrites et les nitrates) par la méthode Kjeldahl. Ces analyses nous ont permis de calculer le rapport C/N pour chacun des échantillons.

Traitement des données

Seules les données des trois stations de 25 × 25 m ont été utilisées lors du traitement à cause du trop petit nombre de *Rhus vernix* retrouvés dans la tourbière Large Teafield. Des histogrammes ont été construits à partir des 8 classes de taille retrouvées dans nos trois stations. Ces distributions de fréquences ont été comparées à l'aide du test de Kolmogorov-Smirnov (Siegel 1956). Ce test consiste à calculer les différences existant entre les distributions de fréquences relatives cumulées de deux échantillons et à vérifier si la plus grande des différences peut être le fruit de fluctuations fortuites d'échantillonnage (Scherrer 1984). La correction de Bonferroni (Harris 1975) a été appliquée pour pondérer la valeur-seuil (α = 0,05) par le nombre de tests effectués.

Résultats

Structure de taille des populations

Le nombre d'individus de *Rhus vernix* retrouvés à l'intérieur du quadrat de 25 × 25 m de l'érablière à *Acer rubrum* de la RNF du lac Saint-François, de l'érablière à *Acer rubrum* et *Betula populifolia* de Saint-Pierre et de l'aulnaie à *Alnus rugosa* et *Acer rubrum* de la RNF était respectivement de 211, 118 et 70, avec des densités estimées respectives de 3376, 1888 et 1120 individus/ha. Nous avons dénombré 17 individus de *Rhus vernix* dans le quadrat de 60 × 70 m de l'érablière à *Acer rubrum* de la tourbière Large Teafield, pour une densité estimée de 40 individus/ha.

Les tests de Kolmogorov-Smirnov entre les trois sites (tableau 1) montrent une différence significative entre les structures de taille des érablières à *Acer rubrum* (RNF et Saint-Pierre)

TABLEAU 1. Tests de Kolmogorov-Smirnov entre les structures de taille des populations de *Rhus vernix* de trois milieux de la municipalité régionale de comté du Haut-Saint-Laurent (site 1: érablière à *Acer rubrum*, Réserve nationale de la faune du lac Saint-François; site 2: érablière à *Acer rubrum* et *Betula populifolia*, Saint-Pierre; site 3: aulnaie à *Alnus rugosa* et *Acer rubrum*, Réserve nationale de la faune du lac Saint-François).

	Site 1	Site 2
Site 1 (n = 211)	—	—
Site 2 (n = 118)	0,1788	—
Site 3 (n = 70)	0,2353*	0,4141*

*Le seuil de signification (α = 0,05) est pondéré par la correction de Bonferroni, soit α/n, où n est le nombre de tests effectués. L'astérisque (*) indique une différence significative.

d'une part et de l'aulnaie d'autre part; par ailleurs, les deux érablières à *Acer rubrum* ne sont pas significativement différentes entre elles à cet égard. En examinant l'histogramme de la figure 2, on observe que les différences entre les distributions sont concentrées dans les classes de faibles tailles, surtout celle regroupant les individus de 50 cm et moins (principalement les semis de l'année). En effet, les semis sont beaucoup moins nombreux dans l'aulnaie que dans les deux érablières.

Espèces compagnes

Le relevé des espèces végétales présentes nous a permis de découvrir qu'*Osmunda cinnamomea*, *Acer rubrum* et *Alnus rugosa* se retrouvent dans les quatre stations échantillonnées; *Osmunda regalis*, *Maianthemum canadense*, *Onoclea sensibilis* dans trois sur quatre et *Ilex verticillata*, *Lycopus uniflorus*, *Carex lacustris*, *Impatiens capensis*, *Parthenocissus quinquefolius*, *Symplocarpus fœtidus* et *Spiraea alba* dans deux.

Production de fleurs et de fruits

L'examen des proportions d'individus ayant fleuri ou fructifié montre que la classe de taille minimale pour la floraison et la fructification des *Rhus vernix* se situe entre 1,5 et 2,0 m. Dans l'érablière de la RNF du lac Saint-François, tous les individus de 2,5 m et plus ont fleuri et une bonne part de ceux-ci ont fructifié (10 sur 15). D'autre part, on constate que dans l'érablière de Saint-Pierre, aucun individu n'a fleuri, même si 15 individus de *Rhus vernix* de cette station ont une taille supérieure à 1,5 m.

Caractéristiques générales des différentes stations

Les caractéristiques générales des quatre stations échantillonnées sont présentées dans le tableau 2. Par importance du couvert végétal, on sous-entend le degré de fermeture de la strate arbustive (comprenant les espèces ligneuses dont la taille varie de 1 à 3 m) pour l'aulnaie et arborée (espèces ligneuses de plus de 3 m) pour les autres stations. Conséquemment, l'érablière de la tourbière Large Teafield est une formation arborée très ouverte, les érablières de la RNF du lac Saint-François et de Saint-Pierre, des formations arborées claires et finalement l'aulnaie de la RNF, une formation arbustive très fermée.

Le dépôt de tourbe est d'épaisseur variable, allant de 30 cm dans l'aulnaie à plus de 140 cm dans l'érablière de la RNF du lac Saint-François. Exception faite de l'aulnaie où l'on retrouve un gleysol humique, le *Rhus vernix* croît sur un sol organique (Commission canadienne de pédologie 1978). Le recouvrement des zones inondées varie selon que l'on se trouve dans un milieu plus sec (érablière de la tourbière Large Teafield) ou dans un milieu très humide où la nappe phréatique demeure toute l'année au-dessus de la surface du sol (aulnaie). Les érablières de la RNF du lac Saint-François et de Saint-Pierre sont inondées au printemps mais le sol s'assèche par la suite et la nappe phréatique descend sous la surface au milieu de l'été. Finalement, le pH de la station de Saint-Pierre est nettement inférieur à celui des autres stations.

Discussion

À sa limite nord de distribution, l'habitat du *Rhus vernix* diffère peu de celui du centre de son aire de répartition, c'est-à-dire en Ohio (Andreas et Host 1983), en Indiana (Lindsey 1931) et en Illinois (Sheviak et Haney 1973) et de l'ouest de son aire (au Minnesota; Buell et al. 1968). Les structures de taille des populations nous révèlent toutefois des faits nouveaux quant à l'influence des communautés végétales sur la colonisation de l'habitat par le *Rhus vernix*. Le nombre de semis est beaucoup moins élevé dans l'aulnaie comparativement à celui des érablières de la RNF du lac Saint-François et de Saint-Pierre. Le couvert végétal beaucoup plus dense de l'aulnaie semble expliquer cette différence. Il est possible que le *Rhus vernix* entre en compétition avec *Alnus rugosa* pour la lumière mais également pour l'espace nécessaire à la croissance des semis. Alnus rugosa est une espèce arbustive très envahissante laissant fort peu de lumière et d'espace au *Rhus vernix* . Le problème de l'espace est d'autant plus marqué dans l'aulnaie que le site est inondé à l'année. Le *Rhus vernix* ne croissant que sur les buttes émergeant de l'eau, la compétition pour l'espace est possiblement très forte. Par contre, dans les deux érablières recensées, le *Rhus vernix* croît dans des formations arborées claires où la lumière est abondante, le couvert végétal étant beaucoup moins fermé. Il y a

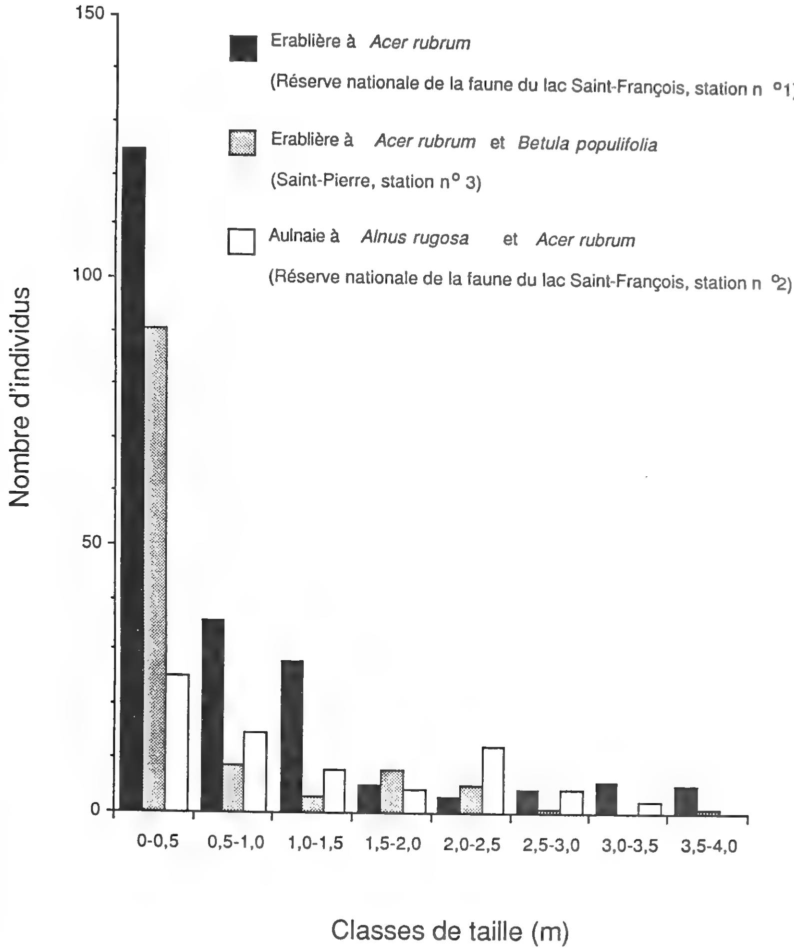

FIGURE 2. Histogramme de fréquence du nombre d'individus de *Rhus vernix* par classe de taille recensés dans trois milieux de la municipalité régionale de comté du Haut-Saint-Laurent.

également beaucoup plus d'espace pour la croissance des semis de *Rhus vernix, Acer rubrum* n'accaparant pas le milieu comme peut le faire *Alnus rugosa* et le milieu n'étant pas inondé à l'année. Cependant la densité de *Rhus vernix* est très faible dans l'érablière à *Acer rubrum* de la tourbière Large Teafield alors que des quatre milieux recensés c'est celui qui est le plus ouvert. On remarque toutefois que c'est la seule station qui n'est pas inondée au moins une partie de l'année (Jean et Bouchard 1987). Or, il est possible que le maintien de la nappe phréatique au-dessus de la surface du sol pendant au moins une certaine période de l'année favoriserait le *Rhus vernix*.

Les données récoltées ne nous permettent pas d'expliquer l'absence de floraison dans l'érablière de Saint-Pierre. Cette érablière diffère peu de celle de la RNF du lac Saint-François (où la floraison est abondante) sauf pour le pH, beaucoup plus faible dans l'érablière de Saint-Pierre. Nous ignorons cependant si cette faible valeur de pH peut inhiber la floraison des individus matures.

La rareté du *Rhus vernix* au Québec pourrait s'expliquer par le fait que l'espèce colonise surtout de jeunes érablières à *Acer rubrum* très humides sur sol organique. Dans les tourbières de Venise Ouest et de Clarenceville (qui sont les seules autres localités québécoises récemment étudiées où l'on trouve du *Rhus vernix*), le *Rhus vernix* ne pousse que dans ce type de milieu (Lavoie 1984). Or, un tel habitat est particulièrement restreint au Québec. Couillard et Grondin (1986) mentionnent ce groupement végétal pour la province uniquement dans les basses-terres du Saint-Laurent à l'ouest de Québec. Bien que cette région soit relativement

TABLEAU 2. Caractéristiques générales des quatre stations échantillonnées dans la municipalité régionale de comté du Haut-Saint-Laurent.

	Erablière à *Acer rubrum* (Réserve nationale de faune du lac Saint-François)	Erablière à *Acer rubrum* et *Betula populifolia* (Saint-Pierre)	Aulnaie à *Alnus rugosa* et *Acer rubrum* (Réserve nationale de faune du lac Saint-François)	Erablière à *Acer rubrum* (Large Teafield)[a]
Classe de milieu humide	Tourbière	Tourbière	Marécage	Tourbière
Importance du couvert végétal (%)	40-60	40-60	> 80	5-25
Physionomie	arborée claire	arborée claire	arbustive très fermée	arborée très ouverte
Dépôt (cm)	> 140	88	30	123
Recouvrement (%), zones inodées	25-49	10-24	≥ 75	1-4
Nappe phréatique, niveau (cm, début juillet)	10	16	-20[b]	18
pH de la tourbe ($CaCl_2$, à 25 cm)	5,8	3,4	5,8	5,4
C (%)	50,3	48,5	48,3	47,1
N total (%)	2,6	1,8	2,9	1,9
C N	19,4	26,8	16,7	25,3

[a]Selon les données de Jean et Bouchard (1987).
[b]Le signe négatif indique un niveau au-dessus de la surface du sol.

vaste, les tourbières et les marécages y demeurent très localisés et sont soumis à de fortes pressions de la part des milieux agricoles et urbains (Grondin et al. 1984). Laframboise (1987) a en effet montré, en colligeant des données de 1917 à 1986, que les superficies occupées par des milieux tourbeux dans une portion du Haut-Saint-Laurent ont diminué de plus de 70%. Il est également possible que des contraintes climatiques empêchent la progression du *Rhus vernix* plus à l'est de la rivière Richelieu. On trouve en effet des érablières à *Acer rubrum* tourbeuses au lac Saint-Paul, près de Trois-Rivières (G. Houle, communication personnelle) et dans la région de Québec (tourbière Les Saules, bois de Champigny; Couillard et Grondin 1986). Toutefois, ces localités sont situées dans des régions ayant un nombre annuel de degrés-jours (> 5°C) inférieur à 1950 (Richard 1987) ce qui pourrait être insuffisant pour la survie de l'espèce. La station de *Rhus vernix* la plus septentrionale (qui est située à Sorel selon Rousseau, 1974) se trouve d'ailleurs à la limite des deux zones bioclimatiques les plus méridionales du Québec, soient l'érablière à Caryer cordiforme et l'érablière à Tilleul d'Amérique (Richard 1987).

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An Update on the Spread of the Antler Moth, *Cerapteryx graminis* (Lepidoptera: Noctuidae), in Newfoundland*

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Morris, Ray F., K. G. Proudfoot, and H. G. Morry. 1991. An update on the spread of the Antler Moth, *Cerapteryx graminis* (Lepidoptera: Noctuidae) in Newfoundland. Canadian Field-Naturalist 105 (1): 78–81.

The Antler Moth, *Cerapteryx graminis* (L.), a pest in lawns, hay and pasture fields, was first discovered in Newfoundland in 1966. The increase of the known geographic distribution between 1979-1987 is described and illustrated, while moth abundance as measured by night light trapping from 1967 to 1987 at Kilbride, Mt. Pearl and Goulds, is discussed. Exotic European parasitoids, *Gonia sicula* (Robineau-Desvoidy) and *Appendicia truncata* (Zetterstedt), are being released in an effort to control this pest.

Key Words: Antler Moth, *Cerapteryx graminis*, Newfoundland, spread, parasitoids, *Gonia sicula, Appendicia truncata*.

The first record of the Antler Moth, *Cerapteryx graminia* (L.), a cutworm species from Europe, was taken in a black light trap at Mt. Pearl, Newfoundland, on 10 August 1966. Morris (1979) recorded the extraordinary build-up of the Antler Moth in Newfoundland during the period 1967-1976, and its subsequent decline in 1977-1978, and compared its life history with that in Great Britain and Europe. Morris (1979) noted that, since its discovery in Mt. Pearl, Newfoundland, the species had spread to infest an area of approximately 60 sq. km. This paper records the further spread of the antler moth in Newfoundland since 1979, moth abundance during the period 1967-1987, and control attempts to date.

Methods

Changes in the known geographical distribution of the Antler Moth in Newfoundland was determined from sporadic field observations, and larval samples submitted by farmers, gardeners and householders to the laboratory for identification and control recommendations. Because of limited resources, no systematic surveys could be undertaken. The gregarious nature of the larvae and the fact that they are diurnal in habit make them readily observable. Also, the larvae have distinctive characteristics (Morris 1979) and cannot be confused with other cutworm species. These characteristics provide suitable criteria for determining distribution patterns.

The abundance of Antler Moths was measured by trapping with a single 15-watt black-light trap operated at each of the following locations: Kilbride, Mt. Pearl and Goulds. The traps were similar to those used by Morris (1979) except that the wattage for all traps was standardized at 15 watts each. They were operated by the authors in their own backyards: Morris, Mt. Pearl; Proudfoot, Goulds; and Morry, Kilbride. All traps were cleared daily and contents examined in the laboratory.

Distribution and Abundance

During the period 1979-1987 the species continued to spread northward to communities on the Trinity and Bonavista peninsulas and southward on the Avalon Peninsula to Cape Broyle (Figure 1). Larvae were collected at Bay de Verde in 1979, indicating the species had crossed Conception Bay, possibly from the Pouch Cove area, an aerial distance of some 40 km. In 1980, the species had moved southward to Cape Broyle. No new infestations were reported in 1981, but in 1982 the species was first recorded at Clarkes Beach. Larvae appeared in large numbers at Avondale and Bell Island in 1983 and in the following year at Blackhead. In 1985, the species had crossed Trinity Bay to infest hay fields and lawns at Maberly, Elliston and English Harbour on the Bonavista Peninsula. In 1986, the following communities reported larval infestations for the first time: Bonavista, Port Union, Musgravetown, Champneys, Port Rexton, Clarenville, Carbonear, Harbour Grace, Upper Island Cove, Bay Roberts and Bay Bulls (Figure 1). No further distributional changes were recorded in 1987. The annual migration rate was approximately 8 km.

Since its capture at Mt. Pearl in 1966, the Antler Moth has successfully established itself throughout a considerable area of eastern Newfoundland and now occupies a large portion of the urban and

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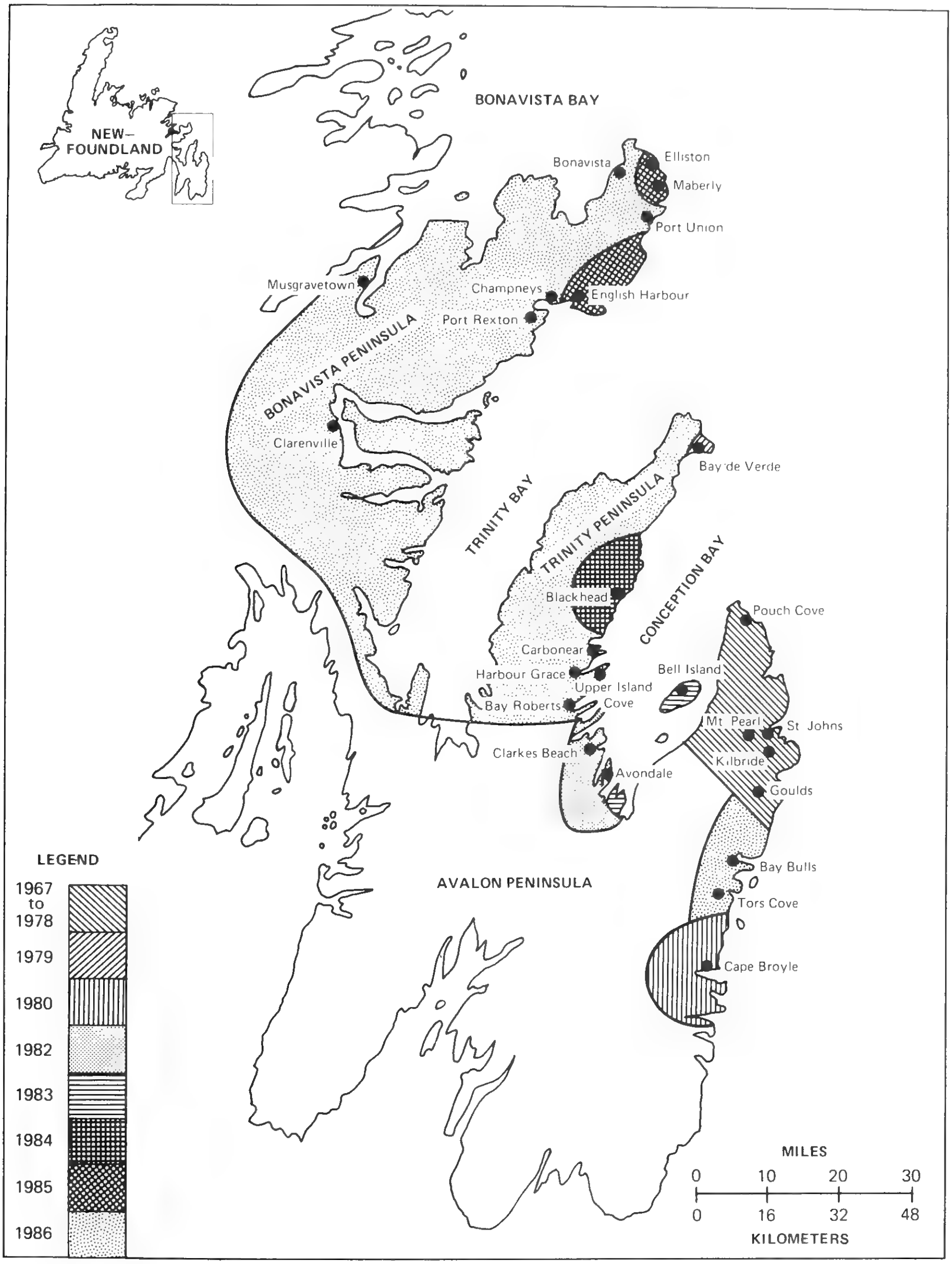

FIGURE 1. Spread of the Antler Moth, *C. graminis* (L.), in Newfoundland during the period 1967 to 1987.

rural areas of the Avalon and Bonavista peninsulas (Figure 1). This pest species has moved rapidly northward across water and relatively slowly westward and southward across the Avalon Peninsula. We suspect that this directional spread is due, in part, to the rocky terrain and sparse vegetation of the southern half of the Avalon Peninsula.

Fluctuations in annual abundance of Antler Moths captured in light traps operated at Mt. Pearl and Kilbride during the period 1967-1987 are illustrated in Figure 2. The light trap at Goulds was operated for a three-year period only – 1985 to 1987 – and the one at Mt. Pearl was not operated in 1985 and 1987. There was a phenomenal

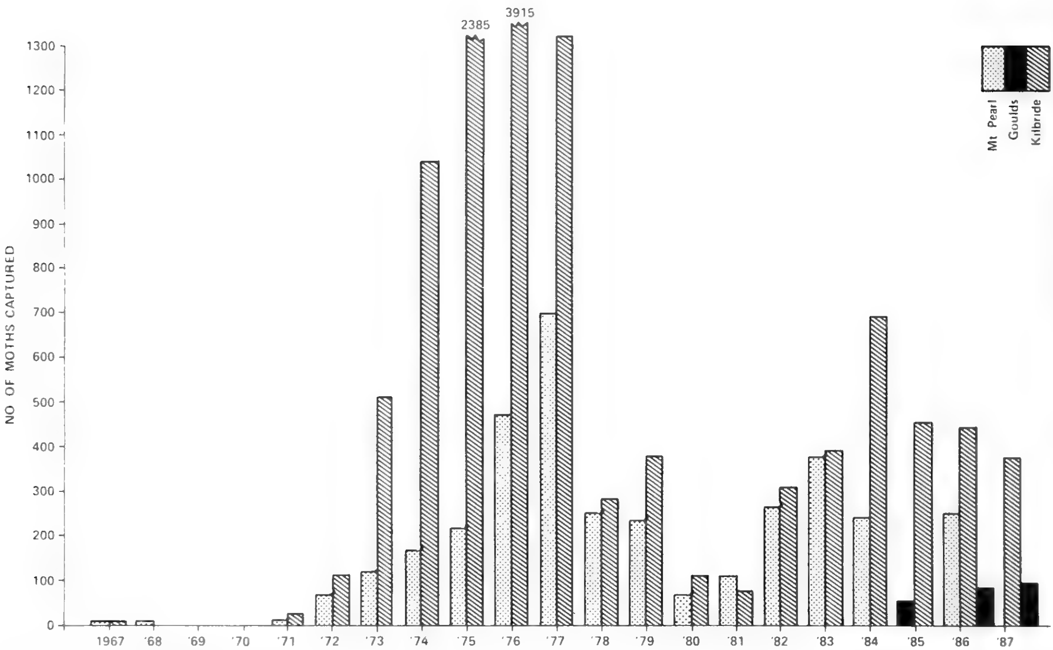

FIGURE 2. Antler Moth adults captured in black light traps operated at Mt. Pearl, Kilbride and Goulds, Newfoundland, during the period 1967 to 1987. (All light traps contained on 15-watt black light fluorescent tube, except the Mt. Pearl light which had a 6-watt black light trap 1967-1978).

increase in the number of moths captured during the period 1967-1977, followed by a collapse in 1978 and fluctuations each year thereafter up to and including 1987 (Figure 2).

During the study period, 1967-1987, the flight period extended from 10 July to 24 September with a peak period of flight from the third week of July to the third week of August. Morris (1979) reported the sex ratio of moths taken in a light trap at Mt. Pearl, 16-20 August 1976, was 63% males and 37% females.

This build-up of the Antler Moth in Newfoundland, its subsequent decline and fluctuating population thereafter is similar to its reported behaviour in the British Isles and Europe. Maercks (1942) reported outbreaks of the Antler Moth were favoured by cool winters and cool summers. Schenker (1950) associated population increase with climatic conditions; early winters, rich in snow, followed by a dry April, a cool May, and abundant grass provided ideal conditions. Entwistle and Rivers (1973) stated that in Great Britain overgrazing on acid moorlands caused fluctuations in Antler Moth populations.

Natural Enemies as Controls

Morris (1979) reported this newly introduced pest species was unusually free from natural enemies as no parasites were obtained from several hundred full grown, field-collected larvae, individually reared in large glass vials. Entwistle and Rivers (1973) reported a similar situation in the British Isles and stated that known natural enemies were few. The larvae are exceedingly difficult to rear to adult stage. In a 1983 rearing experiment with 122 field collected larvae, the incidence of mortality was 78%. A nuclear polyhedrosis virus disease was considered the causal agent but was not confirmed.

On 15 June 1983, 61 tachinid parasites (27 male, 34 female), *Gonia sicula* Robineau-Desvoidy, were received from the Biocontrol Unit, Agriculture Canada, Ottawa. A second shipment (15 male and 17 female) was received on 23 June 1983. These parasites were provided to the Biocontrol Unit by the C.A.B. Institute of Biological Control, Delémont, Switzerland, and had been collected in Holland the previous year. At the St. John's Research Station the tachinid flies were held in four screen cages in an insect rearing room. They were fed a 50/50 solution of honey and water and exposed to Antler Moth larvae contained in a 2 L plastic container with peat and a grass sward in the bottom. Carl and O'Donnell (1982) reported the larval principal host plant was Sheep's Fescue, *Festuca ovina* L., a species widely distributed in Newfoundland and considered naturalized from Europe.

Female flies began laying large numbers of eggs on the grass in the containers on 27 June. One 9 cm blade of grass had 27 eggs attached to its upper surface. Mature eggs are black, umbrella-shaped and measure 0.25×0.12 mm. They were attached to the leaf surface by a mucous surface on their ventral side. Carl and O'Donnell (1982) reported that over 1000 microtype eggs were laid by each female in oviposition cages if dessication was avoided. *G. sicula* eggs have to be ingested by Antler Moth larvae to complete the parasitization process.

During the period 28-29 June 1983, seventy-seven large vials containing a small amount of soil, moistened filter paper, one host larvae and a blade of grass with *G. sicula* eggs attached, were set up in an insectary. Under these conditions larvae refused to feed and few, if any, *G. sicula* eggs were ingested. Host larval mortality reached 78% by 2 July. On 3 July all living *G. sicula* flies and Antler Moth larvae in the inoculation experiment were released on Bell Island where large numbers of host larvae had been observed.

In 1984, because of difficulty in holding and rearing *G. sicula* at the Biocontrol Unit, only four tachinid parasites (1 male and 3 females) were available. These were released in an open field at Brown's Lane, Torbay, on 19 June where Antler Moth larvae were quite active. As funding and personnel for the project were no longer available at the St. John's Research Station in 1985, studies to determine if *G. sicula* had been successfully established at Bell Island and Torbay had to be deferred.

Exotic parasitoids, including *G. sicula* Rapieau-Desvoidy and *Appendicia truncata* (Zetterstedt), are currently being collected in Europe by C.I.B.C., Delémont, for release in Newfoundland in an effort to control this pest.

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Northern Range Extensions of Four Nearshore Marine Fishes in Alaska

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Northern range extensions of *Oxylebius pictus* (Hexagrammidae), *Syngnathus leptorhynchus* (Syngnathidae), *Synchirus gilli* (Cottidae), and *Citharichthys stigmaeus* (Bothidae) are reported. All four species were collected north of 60°N in Prince William Sound in the Gulf of Alaska from April through June 1989. This is the first published account of a verified specimen of *O. pictus* in Alaska.

Key Words: Painted Greenling, *Oxylebius pictus*, Bay Pipefish, *Syngnathus leptorhynchus*, Manacled Sculpin, *Synchirus gilli*, Speckled Sanddab, *Citharichthys stigmaeus*, Prince William Sound, Alaska.

The ichthyofauna of the Gulf of Alaska and adjacent marine waters can be inferred from generalized distributions reported in field guides, checklists, and faunal surveys (Evermann and Goldsborough 1907; Wilimovsky 1954; Clemens and Wilby 1961; Miller and Lea 1972; Quast and Hall 1972; Hart 1973; Peden and Wilson 1976; Eschmeyer et al. 1983; Kessler 1985; Rogers et al. 1986). Northward extensions of the documented ranges for some species in Alaska have also been reported (Townsend 1935; Miller and Erdman 1948; Hubbard and Reeder 1965; Quast 1968; Peden and Jamieson 1988). Distributional accounts of some nearshore marine fishes are limited because their geographic ranges are broad and extend across unsampled or sparsely sampled areas. Prince William Sound in the northern Gulf of Alaska has a diverse marine fauna that has received relatively little study (Rogers et al. 1986).

During beach-seine sampling for juvenile salmonids in the Sound, four fish species were found north of their published ranges: Painted Greenling (*Oxylebius pictus*), Bay Pipefish (*Syngnathus leptorhynchus*), Manacled Sculpin (*Synchirus gilli*), and Speckled Sanddab (*Citharichthys stigmaeus*). Here we report collection dates, localities, and specimen sizes, and give a brief zoogeographic account for each species.

Methods

We sampled the nearshore ichthyofauna at numerous sites in Prince William Sound, Alaska, April through June 1989 (Figure 1). Sites were categorized according to beach gradient: low (< 10% slope), medium (11–25% slope), and steep (> 50 slope). In general, substrate increased in size as beach gradient increased in slope. Temperature and salinity were recorded at the 0.5 m depth with a Beckman RS5-3[1] portable induction salinometer, and macrophyte coverage was noted. We used two styles of beach seines: one for low and medium gradient beaches, and another for steep gradients. The first was a standard beach seine, 37 m long with five mesh sections. The bunt (0.6 cm square green mesh) was 9 m long and tapered from 5 m to 4 m wide from the center to either inner wing. The two 4 m long inner wings (1.3 cm square green mesh) tapered to 3 m at the lead wings. The two 10 m long lead wings (3.2 cm square white mesh) tapered to 1 m at each end of the seine. The second seine was 37 m long and 3 m deep with three mesh sections. The bunt (0.6 cm square green mesh) was 17 m long with a floor area formed by a 9 m lead line that was connected to each bunt-wing intersect; the two wings were each 10 m long (3.2 cm square white mesh). The front edge of the floor was bordered with a 0.75 m strip of black vinyl that tapered to each bunt-wing intersect. The vinyl strip of this seine permitted it to glide over rocky substrate that would normally hang up a standard beach seine.

Results and Discussion

HEXAGRAMMIDAE

Oxylebius pictus, Painted Greenling

Oxylebius pictus is a small cryptic fish that was first noted by Gill (1862) in a collection of California fishes (no locality given). Published distribution of *O. pictus* extends northward from Point San Carlos, Baja California (27°24′N, 112°26′W; Miller and Lea 1972) to Brundige Inlet, British Columbia (54°37′N, 130°51′W; Peden and

[1]Reference to trade names does not imply endorsement by the National Marine Fisheries Service.

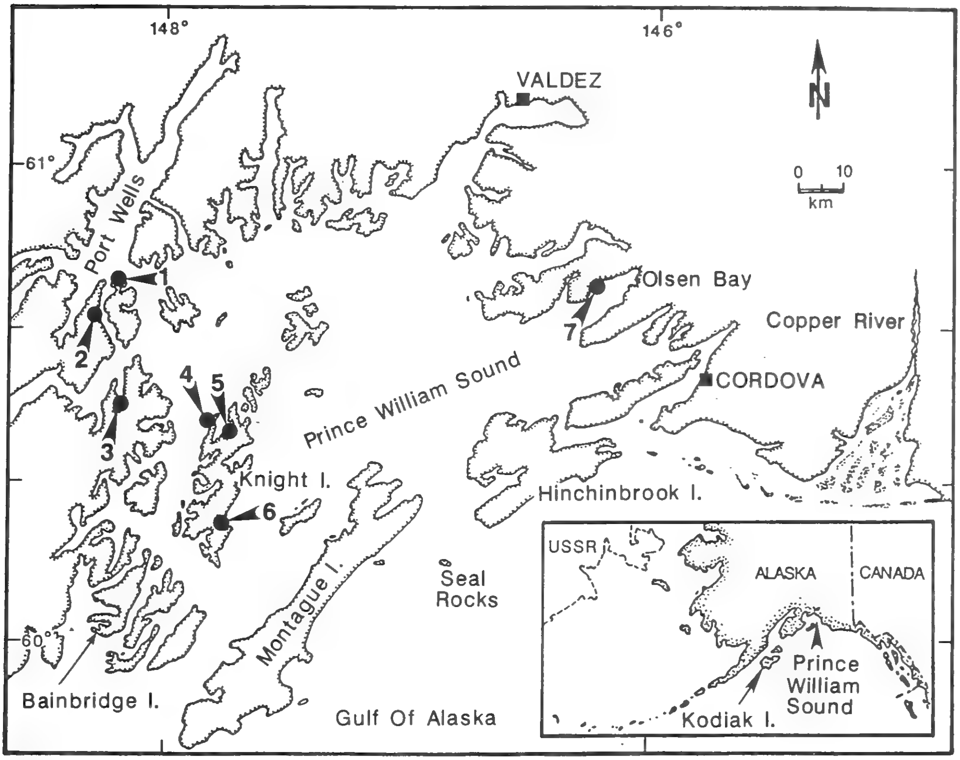

FIGURE 1. Seven nearshore marine sampling sites in Prince William Sound, Alaska: 1 = Wells Passage, 2 = Long Bay, 3 = McClure Bay, 4 = Knight Island Passage, 5 = Herring Bay, 6 = Snug Harbor, and 7 = Olsen Bay.

Wilson 1976). Eschmeyer et al. (1983) reported *O. pictus* ranging to Kodiak Island, Alaska; this, however, was in error (W. N. Eschmeyer, California Academy of Sciences, personal communication). We know of two unpublished capture localities for this species in southeastern Alaska: Steamer Bay [specimens catalogued at Auke Bay Fisheries Laboratory Museum (ABL) as AB78-59 and AB82-3]; and Aleutkina Bay (P. F. Hassermer, presently at Idaho Department of Fish and Game, personal communication).

Our *O. pictus* specimen was collected adjacent to a steep rock face on 18 June 1989 in Snug Harbor, Prince William Sound (Table 1). The rocky slope was covered with filamentous algae, and *Laminaria* sp. was present along the lower edge of the seining area. At time of capture, temperature was 9.9° C and salinity was 29.0 ppt. The specimen was 122 mm total length (TL), considerably less than the 254 mm TL maximum size reported by Clemens and Wilby (1961). This account extends the published range of *O. pictus* northwestward by 1325 km. *Oxylebius pictus* therefore appears to have a continuous distribution of about 4200 km from southcentral Alaska to Baja California based on our account along with other records (e.g., Jordan and Gilbert 1881; Evermann and Goldsborough 1907; Starks 1911; Clemens and Wilby 1961; Barraclough et al. 1968; DeLacy et al. 1972; Davis et al. 1981).

Peden and Wilson (1976) described *O. pictus* as elusive, inhabiting steep, rocky areas with deep crevices. In addition, Eschmeyer et al. (1983) reported this species rare north of Washington. This combination of elusiveness and rarity may explain why little documentation exists for *O. pictus* in Alaska.

SYNGNATHIDAE

Syngnathus leptorhynchus, Bay Pipefish

Girard (1854) first published an account of *Syngnathus leptorhynchus* from observations made in San Diego, California. This fish is abundant in the eastern Pacific and ranges farther north than any other *Syngnathus* species (Fritzsche 1980). The published distribution of *S. leptorhynchus* is from Santa Maria Bay, Baja California (24°47′N, 112°16′W; Fritzsche 1980), northward to Sitka, Alaska (57°02′N, 135°08′W; Herald 1941). However, unpublished data exists

TABLE 1. Occurrence of *Oxylebius pictus*, *Syngnathus leptorhynchus*, *Synchirus gilli*, and *Citharichthys stigmaeus* in the nearshore marine waters of Prince William Sound, Alaska, 1989.

Species	Date	Capture Sites	Coordinates		n	Total Length Range (mm)	Catalogue Number
Oxylebius pictus	18 June	Snug Harbor	60°16′N	147°46′W	1	122	AB89-21
Syngnathus leptorhynchus	10 April	Olsen Bay	60°44′N	146°14′W	15	—	
	29 April	Herring Bay	60°27′N	147°42′W	1	—	
	14 May	Herring Bay	60°27′N	147°42′W	10	—	
	15 May	McClure Bay	60°30′N	148°10′W	10	—	
	16 May	Long Bay	60°42′N	148°16′W	3	—	
	21 May	Wells Passage	60°45′N	148°11′W	1	228	AB89-25
	24 May	Long Bay	60°42′N	148°16′W	3	186	AB89-26
	30 May	Herring Bay	60°27′N	147°42′W	45	—	
	30 May	McClure Bay	60°30′N	148°10′W	6	—	
	15 June	Herring Bay	60°27′N	147°42′W	13	—	
	15 June	McClure Bay	60°30′N	148°10′W	1	—	
	16 June	McClure Bay	60°30′N	148°10′W	6	—	
	16 June	McClure Bay	60°30′N	148°11′W	4	—	
	17 June	Long Bay	60°42′N	148°16′W	4	—	
	17 June	Long Bay	60°41′N	148°17′W	1	—	
	18 June	Snug Harbor	60°16′N	147°46′W	6	105-337	
	21 June	Herring Bay	60°27′N	147°42′W	10	194-304	
	22 June	McClure Bay	60°30′N	148°10′W	118	104-333	AB89-27
Synchirus gilli	19 May	Knight Is. Passage	60°28′N	147°47′W	2	47-52	AB89-22
	19 May	Knight Is. Passage	60°27′N	147°48′W	1	—	
	19 May	Knight Is. Passage	60°28′N	147°48′W	1	—	
	21 May	Wells Passage	60°45′N	148°11′W	1	—	
	19 June	Knight Is. Passage	60°28′N	147°48′W	4	51-57	AB89-23
	20 June	Wells Passage	60°45′N	148°11′W	3	22-55	AB89-24
Citharichthys stigmaeus	23 May	McClure Bay	60°30′N	148°11′W	1	103	AB89-19
	22 June	McClure Bay	60°30′N	148°10′W	3	51-93	AB89-20

on specimens collected from the northern Gulf of Alaska and Prince William Sound [catalogued at the Canadian Museum of Nature (NMC) as NMC 61-0096, -0097, -0098, -0132; all NMC specimen information is provided courtesy of D. E. McAllister].

We collected 257 *S. leptorhynchus* specimens at eight sites in Prince William Sound from April through June 1989 (Table 1). *Syngnathus leptorhynchus* was most abundant over beaches of medium gradient with extensive eelgrass (*Zostera marina*) beds. Temperature and salinity at the capture sites ranged from 4.7 to 11.0°C and from 5.2 to 30.6 ppt. Our collection of *S. leptorhynchus* represents a northwestern range extension of 850 km from the previously published northern range of this species. Specimen abundance and wide distribution within Prince William Sound indicate an established residence in the Sound. Our account of *S. leptorhynchus*, together with others' (e.g., Evermann and Goldsborough 1907; Starks 1911; Miller and Lea 1972; Hart 1973; Bayer 1980; Allen 1982; unpublished ABL records AB64-32, -35, -41, -956, AB67-6, AB83-38; unpublished NMC records NMC61-0013, -0162), suggests a continuous distribution of about 4900 km from southcentral Alaska to Baja California.

We measured 130 *S. leptorhynchus* and found a size structure similar to that recorded for southern specimens. Individuals from our June sample

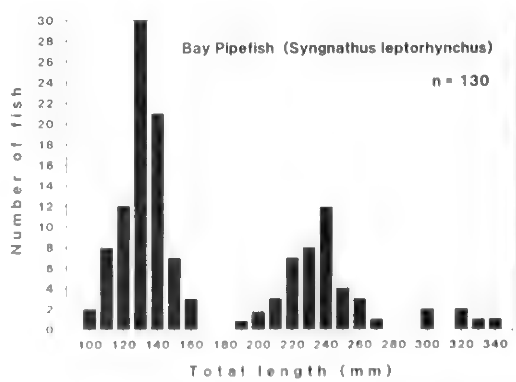

FIGURE 2. Length composition of *Syngnathus leptorhynchus* (Bay Pipefish) collected at three nearshore marine sites of Prince William Sound, Alaska, 18–22 June 1989.

ranged in size from 104 to 337 mm TL and comprised three distinct size classes (Figure 2). From Yaquina Bay, Oregon, Bayer (1980) similarly reported three age-groups of *S. leptorhynchus* with fish as small as 110 mm TL in June. Our largest specimen was smaller than the maximum recorded length (385 mm, Bayer 1980) for this species.

COTTIDAE

Synchirus gilli, Manacled Sculpin

Synchirus gilli was first described by Bean (1890) from Barkley Sound, British Columbia. Published accounts show this species to occur as far south as San Miguel Island, California (34°01′N, 120°12′W; Miller and Lea 1972), and in Alaska as far west as Kodiak Island (57°03′N, 153°38′W; Harris and Hartt 1977) and as far north as Funter Bay (58°15′N, 134°56′W; Orsi and Landingham 1985). Unpublished data exists on the occurrence of *S. gilli* in the northern Gulf of Alaska and southern Prince William Sound (specimens catalogued as NMC 61-0128,-0129,-0132,-0142).

We collected 12 specimens of *S. gilli* at four sites in Prince William Sound during May and June 1989 (Table 1). Macrophyte coverage consisted of filamentous algae, *Z. marina, Fucus* sp., and *Laminaria* sp. Temperature and salinity at four capture sites ranged from 6.2 to 8.1°C and from 26.9 to 28.7 ppt. We found *S. gilli* over low, medium, and steep gradient beaches. The seven specimens we measured ranged from 22 to 57 mm TL, smaller than the 69 mm TL maximum size described in Miller and Lea (1972). Our specimens from Prince William Sound represent a range extension of 800 km from the previous northern limit published by Orsi and Landingham (1985). From a zoogeographic perspective, this indicates that *S. gilli* is not restricted in its northward occurrence to 58°N, and is not distributed as two separate populations on each side of the Gulf of Alaska. Moreover, additional records (e.g., Chapman and DeLacy 1933; Miller and Erdman 1948; Bolin 1950; Walker 1953; Krejsa 1964; Hart 1973; unpublished ABL record AB83-23; unpublished NMC record NMC 61-0163) further suggest a continuous distribution of about 3600 km for *S. gilli* from the western Gulf of Alaska to California.

BOTHIDAE

Citharichthys stigmaeus, Speckled Sanddab

Citharichthys stigmaeus was first described by Jordan and Gilbert (1882) from a collection obtained at Santa Barbara, California. The southern range of this species extends to Magdalena Bay, Baja California (24°43′N, 111°59′W; Miller and Lea 1972). The northern range limit is generally published as southeastern Alaska (Wilimovsky 1954; Clemens and Wilby 1961; Quast and Hall 1972; Hart 1973; Eschmeyer et al. 1983), although Townsend (1935) published an account of one *C. stigmaeus* specimen collected farther north at Hanning Bay, Montague Island in southcentral Alaska (59°58′N, 147°43′W).

We collected four *C. stigmaeus* specimens at McClure Bay in Prince William Sound during May and June 1989 (Table 1). Temperature and salinity at two sites adjacent to the capture sites ranged from 8.2 to 11.3°C and from 12.6 to 16.2 ppt. We captured *C. stigmaeus* over low gradient beaches where sparse algal mats and *Fucus* sp. were present. The specimens ranged from 51 to 103 mm TL, less than the 170 mm TL maximum size given in Miller and Lea (1972). Our specimens represent a northern range extension of 65 km and corroborate the account of Townsend (1935). *Citharichthys stigmaeus* appears to have a continuous distribution of about 4900 km from southcentral Alaska to Baja California based on our documentation along with other records (e.g., DeLacy et al. 1972; Pearcy and Myers 1974; Cross et al. 1978; Hogue and Carey 1982; Hobson and Chess 1986; unpublished ABL records AB69-52, AB78-58; unpublished NMC records NMC 61-0072, -0075).

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Sympatric Presence of Dwarf and Normal Forms of the Lake Whitefish, *Coregonus clupeaformis*, in Como Lake, Ontario*

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Bodaly, R. A., J. Vuorinen, and V. Macins. 1991. Sympatric presence of dwarf and normal forms of the Lake Whitefish, *Coregonus clupeaformis*, in Como Lake, Ontario. Canadian Field-Naturalist 105(1): 87–90.

The presence of a dwarf form of the Lake Whitefish, living sympatrically with a normal sized Lake Whitefish form, is documented for Como Lake, northern Ontario. Gillnet catches on a shoal revealed two distinct size classes of spawning fish, with modal sizes of 170–179 mm and 280–289 mm fork length. Dwarfs grew more slowly and had shorter life spans as compared to normals. Gillraker numbers for the two forms were slightly different ($p = 0.025$) with a mean of 24.4 for dwarfs and a mean of 25.0 for normals. Both forms had modal gill raker counts of 24. The dwarf whitefish of Como Lake are the only sympatric dwarf whitefish known in the central part of the range of the species, outside of Algonquin Park, Ontario.

Key Words: Lake Whitefish, dwarf, evolution, zoogeography, Como Lake, Ontario.

Instances of closely related sympatric forms of Lake Whitefish (*Coregonus clupeaformis*) are of great evolutionary, zoogeographic and ecological significance. Lakes supporting such sympatric forms are rare (Lindsey et al. 1970). Outside of Ontario, there are seven such lakes in Canada; four in the Yukon (Bodaly 1979), two in Quebec (Gendron and Fortin 1984), and one in Labrador (Bruce 1984) as well as a number in Maine (Fenderson 1964). In Ontario, dwarf Lake Whitefish were previously known only from lakes in Algonquin Park (Kennedy 1943). This contribution documents the presence of dwarf Lake Whitefish in Como Lake, Ontario.

Study Site

Como Lake is located near Chapleau, Ontario, in the headwaters of the Michipicoten River basin, tributary to Lake Superior (47°55′N; 83°30′W). The lake has a surface area of 1596 ha and is about 10 km long on the longest axis. It has a mean depth of 9.4 m and a maximum depth of 26.0 m. Total dissolved solids in early June 1978 were 59.0 mg/l (Ontario Ministry of Natural Resources, Chapleau, unpublished data). Besides Lake Whitefish, there are 12 other fish species in Como Lake, including White Sucker, *Catostomus commersoni*, Lake Trout, *Salvelinus namaycush*, Walleye, *Stizostedion vitreum*, Yellow Perch, *Perca flavescens*, Round Whitefish, *Proposium cylindraceum*, Burbot, *Lota lota*, and Northern Pike, *Esox lucius*. There are apparently no cisco species (*Coregonus artedii* and others) in Como Lake. It is located in the Chapleau Crown Game Preserve. There is a sport fishery for game fish but there has never been a commercial fishery on the lake.

Methods

Fish were captured with experimental gillnets, each of total length 90 m and depth 2 m with six panels of stretched mesh sizes of 3.8 cm (1½ in), 5.1 cm (2 in), 7.0 cm (2¾ in), 8.9 cm (3½ in), 10.8 cm (4¼ in), and 13.3 cm (5¼ in). Two nets were set overnight 25–26 October 1989 nearshore on a rocky shoal in about 2–4 m of water. Surface water temperatures were 7.0–7.5°C. A total of 415 whitefish were captured. Fish lengths were measured to the nearest mm and sex and spawning condition were determined by squeezing the abdomen of all fish. Fish which were not ripe and running were sexed internally. The total number of gillrakers on the first gill arch on the left side was counted and ages were determined from pelvic fin sections on a random sample of 25 dwarf and 25 normal whitefish.

*Contribution Number 3 in the Program of Joint Investigation of Holarctic Fishes among the U.S.S.R., Canada, Finland and Poland.

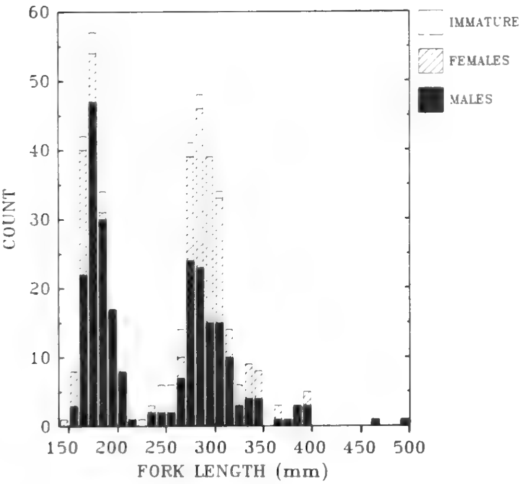

FIGURE 1. Length, sex and maturity of Lake Whitefish caught 25–26 October 1989, Como Lake.

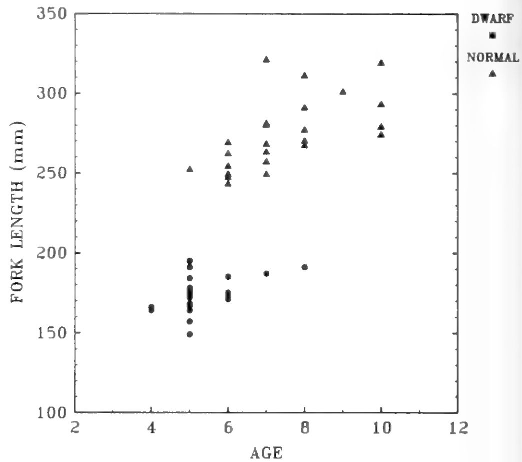

FIGURE 2. Fork length versus age for dwarf and normal Lake Whitefish, Como Lake.

Results

The length-frequency distribution of Lake Whitefish caught was distinctly bimodal, with modes at 170–179 mm fork length and 280–289 mm fork length (Figure 1). Only 8 mature fish were found in the range 210–259 mm fork length. Most fish in both size modes were in spawning condition. Both modes contained fish of both sexes. Sexually mature fish (mature, ripe and running, or spent) in the smaller size range (below 220 mm) are hereafter called dwarfs and sexually mature fish in the larger size range are called normals. The sex ratio for dwarfs was 4.1:1 (males to females) and for normals was 1.2:1. Dwarf males were larger than dwarf females (mean fork lengths 179 and 166 mm, t-test $P < 0.001$) whereas normal males were not significantly different in mean length from normal females (mean fork lengths 299 and 297, respectively, t-test $P = 0.72$).

The ages and growth of dwarfs and normals were distinctly different. Dwarfs ranged in age from 4 to 8 yr (mean 5.3) and few were older than 6 whereas normals were 5 to 10 yr (mean 7.4). The size distribution of fish in the ages of overlap between the two forms (5–8) was distinctly bimodal, with the normals being much larger than the dwarfs (Figure 2). Dwarfs grew much slower, matured earlier and at a much smaller size, and did not live as long as normals (Figure 2).

Gill raker counts were similar but statistically different for dwarf and normal Lake Whitefish. The modal count for both groups was 24 (ranges: 23–27 for dwarfs and 24–26 for normals), but the means for the two groups (for dwarfs 24.4 and for normals 25.0) were significantly different (t-test $P = 0.025$). It is possible that this difference in mean gill raker counts is due to counting difficulties because the smallest rudimentary raker could have been missed more often on the smaller dwarf fish.

Discussion

This evidence demonstrates the presence of two forms of Lake Whitefish in Como Lake. Examination suggests differences in meristic counts, in addition to gill raker number, between the two forms. This indicates that the two forms are probably at least partially reproductively isolated from each other, as has been shown for other sympatric coregonid populations (eg. Bodaly 1979; Gendron et Fortin 1984). The two forms appear to spawn at the same time and together on at least one spawning shoal. Dwarfs and normals in spawning condition were both caught on two other shoals in netting conducted by one of us (VM) in the autumn of 1965. Como Lake has no inlet streams of appreciable size which could be utilized for spawning. Therefore, any reproductive isolation must be maintained by behavioural mechanisms at the time of spawning. Hybrids might be difficult to identify, depending on the degree of genetic differentiation between the two forms, because gill raker counts overlap to a great extent.

As for many other populations of dwarf whitefish, the Como Lake dwarfs survive in the absence of any cisco species, and may not be able to survive competition with ciscoes. The smaller of the two forms of Lake Whitefish in Yukon lakes occurs only in the absence of the Least Cisco, *Coregonus sardinella*, (Bodaly 1979), and ciscoes did not occur naturally in Opeongo and Bark

lakes, in the Algonquin Park area, the only other Ontario lakes known to support dwarf whitefish. Ciscoes were introduced into Opeongo Lake in 1948. The introduction of cisco probably caused a reduction in the abundance of dwarf whitefish (Lindsey 1981), but dwarf Lake Whitefish still survive in the lake (D. O. Evans, Ontario Ministry of Natural Resources, Maple, personal communication). Cisco and Rainbow Smelt, *Osmerus mordax*, are also now in Bark Lake. Introduction of cisco or smelt into Como Lake could cause the extinction of this population and should be avoided. Transplanting the Como Lake dwarfs into other lakes as a means of ensuring its survival could be considered. Candidate lakes should have no cisco or smelt populations, and because of the possibility of introgressive hybridization with normal Lake Whitefish, recipient lakes should probably also not have any Lake Whitefish. Spawning shoals should be present because the Como Lake dwarf Lake Whitefish is apparently not adapted to stream spawning.

The Lake Whitefish populations of Como and Opeongo lakes share many similarities in ecological characteristics. Kennedy (1943) reported that mature Opeongo dwarfs ranged in size from 110–130 mm SL (standard length) whereas mature normals ranged in size from about 180 to over 300 mm SL. Few mature fish in the range 14–17 cm SL were found in Opeongo. These sizes are quite similar to those for Como Lake. Opeongo dwarfs also had slightly fewer gillrakers than normals, with a mean of 25.4 gillrakers compared to 27.7 for normals (Kennedy 1943). Kennedy found Opeongo dwarfs essentially stopped growing after their second year of life and that few fish older than four were found, whereas Como dwarfs were older and continued to grow slowly up to at least eight years. However, Como Lake fish were aged with fin ray sections whereas Opeongo fish were aged with scales, which may tend to underestimate ages. Opeongo normals showed increases in size up to 12 years old (Kennedy 1943). The oldest normal from Como Lake was found to be 10 yr although the largest fish in the small sample aged was only 321 mm Fork Length (see Figure 1).

Whether the Como and Opeongo dwarf whitefish share a common evolutionary origin is not clear at present. Como and Opeongo lakes are not very close to each other (Opeongo Lake is in the headwaters of the Madawaska River which flows to the Ottawa River, tributary to the St. Lawrence), being almost 500 km apart by straight line and much farther by the nearest water connection. However, the two areas were much more closely connected by water in the late Pleistocene period than is the case today (Underhill 1986). The North Bay outlet of Lake Nippissing I was formed about 6000-5700 y ago and existed for perhaps 1000 y. This outlet drained the upper Great Lakes into the Ottawa River as the area containing present-day Como Lake became ice free, thus allowing relatively easy transfer of fish between the two areas (Underhill 1986). However, despite the closer proximity of lakes supporting sympatric populations of Lake Whitefish in the Yukon, biochemical evidence points to a polyphyletic origin for the four populations of high gill raker (dwarf) Lake Whitefish in Yukon lakes (Bodaly et al. 1988). Samples collected from Como Lake are currently the subject of research into allozyme genetics and mtDNA patterns to determine the degree of genetic differentiation between the two forms and to determine possible affinities with other sympatric forms of Lake Whitefish in North America, especially with those in Lake Opeongo.

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New Examples of the Moonwort Hybrid, *Botrychium matricariifolium* × *simplex* (Ophioglossaceae)

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Wagner, Warren, H., Jr. 1991. New examples of the moonwort hybrid, *Botrychium matricariifolium* × *simplex* (Ophioglossaceae). Canadian Field-Naturalist 105(1): 91–94.

Known previously from only two localities in Michigan, two new specimens of the moonwort hybrid, *Botrychium matricariifolium* × *simplex*, are reported in herbarium collections from Gaspé Co., Quebec. These are of special interest for representing only the third locality reported, 1930 km northeast of the previous ones, the plants themselves much larger and better developed than the earlier ones. A detailed key separates the hybrid from both its parents, as well as from *B. lanccolatum*, the orthospecies with which it is most likely to be associated.

Key Words: Moonworts, *Botrychium matricariifolium, B. simplex,* Ophioglossaceae, hybridization, hybrid characters.

Moonworts are mostly minute ferns that occur in disturbed sites. Because of their inconspicuousness, rarity, often brief seasonal appearance, few and often subtle characters, and commonly poorly-pressed herbarium specimens, the moonworts have been until recently a neglected and poorly understood group. Intensive field studies over the past decade have revealed a number of previously unrecognized divergent species (orthospecies), as well as interspecific hybrids (nothospecies). Hybridization is promoted by the commonly close proximity of the parents in *Botrychium* communities, where a number of taxa may grow together. The nothospecies can be determined by (a) association with the parents, (b) intermediate leaf morphology, (c) abortive spores, and (d) irregular meiosis. The first three of these sources of evidence for a hybrid hypothesis are considered to provide strong support, especially leaf morphology.

The first presumed hybrid moonwort from the New World was described only a decade ago (Wagner 1980). Two collections from central Michigan were reported of the cross between Matricary Moonwort, *B. matricariifolium* A. Br., and Least Moonwort, *B. simplex* E. Hitchc., the two commonest moonworts in eastern North America. Subsequently other hybrids have been described, many of them from the west. In the Lake Superior region, we now have reported five hybrid combinations (Wagner and Wagner 1988). As in a number of other fern genera, e.g., *Asplenium, Dryopteris,* and *Woodsia*, congeneric species tend to occur together in the same habitats, forming genus communities. In *Botrychium* and *Ophioglossum*, this tendency reaches an extreme, and we have discovered as many as 11 species co-occurring (Wagner and Wagner 1985), making it possible to delineate the basic species and detect occasional hybrids. The actual number of hybrids we have found is, however, exceedingly small; indeed, most are from only a single specimen. The outstanding exception is the Waterton Lakes hybrid moonwort, *Botrychium* × *watertonense* W. Wagner, the nothospecies that combines the very different characteristics of the fertile orthospecies, Western Moonwort, *B. hesperium* (Maxon and Clausen) Wagner and Lellinger, and Paradox Moonwort, *B. paradoxum* W. Wagner, that grow with it. There are probably hundreds of plants of the Waterton hybrid at the locality, which we have not yet thoroughly censused; of the three taxa in our sample, nearly one-fourth were the hybrid (Wagner et al. 1984).

The Matricary × Least Moonwort hybrid is here reported from a new locality. This is of interest for several reasons: (a) the locality is only the third one reported; (b) it is nearly 1930 km to the northeast of the previous ones; (c) the plants themselves are far better developed and larger than those already described; and (d) it is now possible to provide a key to separate out the hybrids using fully mature individuals.

The data on the new collection are as follows: Canada, Quebec, Gaspe Co., St. Ann des Monts. On flat, sandy summit of partly wooded hill, growing with *B. simplex* and *B.* [*lanceolatum* var.] *angustisegmentum.* 29 June 1929. *L. McI. Terrill 1621* (CAN). Of the six plants on the sheet (Figure 1), one is *B. lanceolatum* (C), three are *B. matricariifolium* (B, D, F), and two are the hybrid discussed here (A and E). An enlargement (Figure 2) of plants D, E, and F is presented to show the characters of the hybrid (2). All of the specimens are large and well-developed. The hybrids have leaves that average 22.2 cm tall, the trophophores average 7.6 cm long. The previously reported hybrids had leaves that average 16.5 cm

FIGURE 1. Herbarium sheet showing three taxa: *B. matricariifolium* (B,D,F), *B. lanceolatum* ssp. *angustisegmentum* (C), and *B. matricariifolium* × *simplex* (A,E).

tall, the trophophore 5.2 cm long. The newly recognized individuals are thus over a third again as large.

It may be that *B. matricariifolium* × *simplex* will prove to be more frequent than expected. The parents, together with *B. lanceolatum* ssp. *angustisegmentum* are the most commonly encountered moonworts in eastern North America. Cody and Britton (1989: maps 59,60,64) show their distributions. Matricary and Least Moonworts often occur side-by-side. (Indeed in our research on botrychiums we have stopped collecting samples of this mixture in nature). The parents are abundantly represented in herbaria, and except for certain peripheral localities, most occurrences are uninteresting. On the other hand, if we actually do search for the hybrid we should be

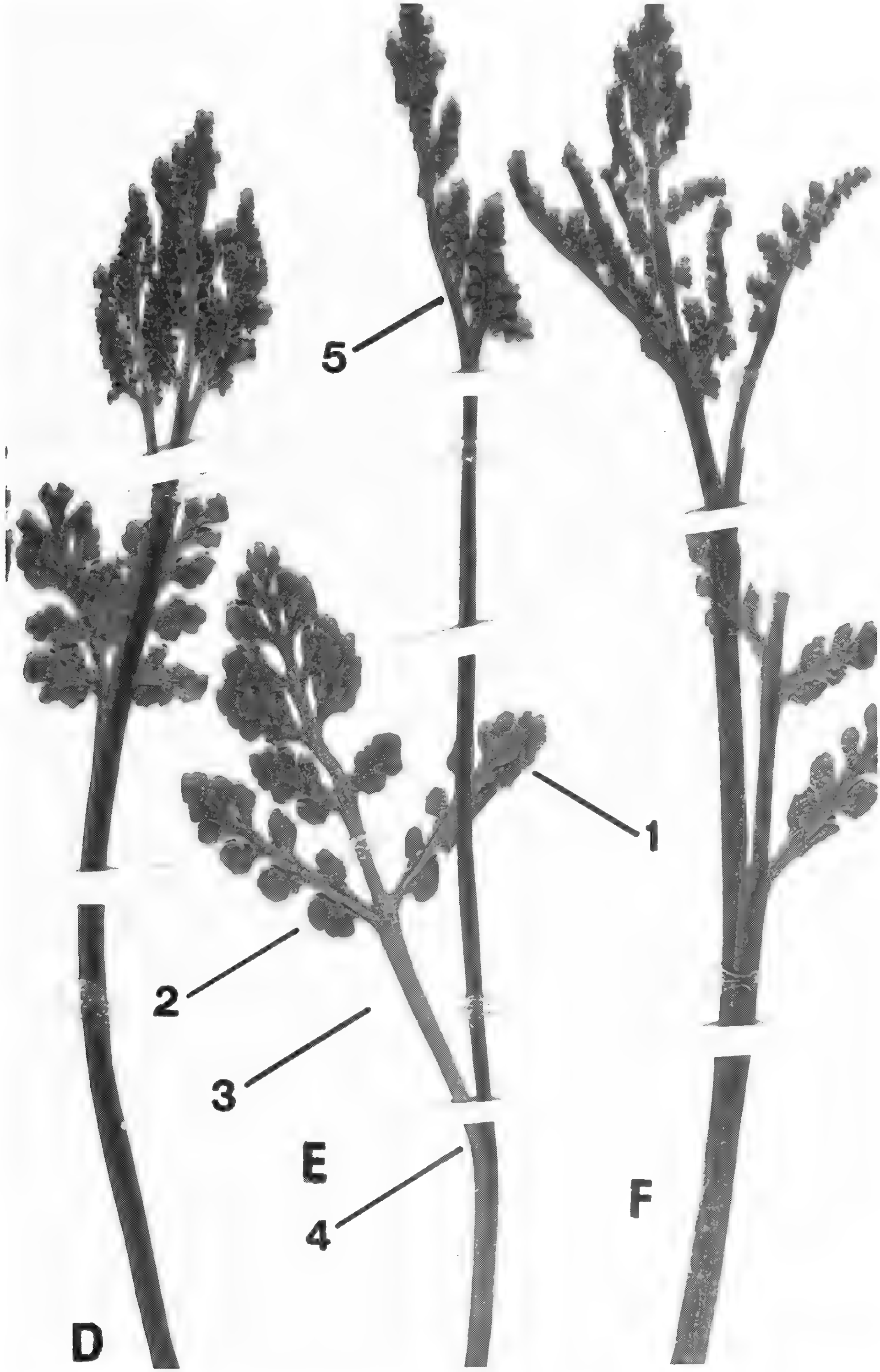

FIGURE 2. Close-up of *B. matricariifolium* × *simplex* (E). Note (1) large basal pinnae, (2) rounded segments, (3) long petiole, (4) low origin of sporophore, and (5) once-pinnate sporangial cluster.

able to mark it and make detailed studies of its habitat and especially its chromosomes. The hybrid spores are obviously abortive, indicating that meiosis is irregular. But, in connection with the possibility that *B. simplex* may be involved in the origin of *B. matricariifolium* (the former is a diploid, with n = 45; the latter a tetraploid, with n = 90, suggesting that *B. matricariifolium* itself arose as a hybrid), it would be highly desirable to determine whether pairing takes place. Thus, we recommend that field workers be alert to the possibility of locating new individuals so that they can be designated for future studies. The fact that the collector, Terrill, obtained two superb individuals of the hybrid at the Quebec locality is especially encouraging.

Key to hybrid *Botrychium matricartifolium* × *simplex* and three orthospecies.

The following key places the hybrid in the context of three orthospecies with which it is most likely to be associated. For making useful herbarium vouchers, it is desirable that the leaves be pressed carefully in an old telephone directory or other catalogue, so that the segments can be teased out completely and the sterile segment or trophophore blade is perfectly flat. After 4–6 hours of preliminary pressing, the directory should be opened, and the specimens checked to see that they are spread out to expose the shapes and orientation of the pinnae and pinnules.

1. Trophophore deltate, arising near top of plant; pinnae linear, pointed, the median ones less than 3 mm wide; color dark shiny green; sporophore branched mainly well below the middle into 2–5 more or less equal major upright to spreading axes (Figure 1C).
Botrychium lanceolatum ssp. *augustisegmentum* (Fern.) Clausen

1. Trophophore oblong to oblong-deltate, arising above to below middle of the plant; pinnae oblong-lanceolate, ovate to spatulate, tips rounded to truncate, the median ones more than 5 mm wide; color light dull green; sporophore branched mainly above the middle, only 1–3 unequal major upright to spreading axes.

   2. Trophophore mostly arising below the middle of the plant, its petiole ¾ to 1 or more × as long as the blade; blade simple, lobed, or pinnate, the lobes or pinnae strongly asymmetrical; pinna pairs usually less than 5; basal pinnae simple and conform or lobed or pinnulate and enlarged, 1–3 × as long as adjacent pinnae; blade apex rounded and coarsely lobed; sporophore with one main axis and usually once divided. *B. simplex* E. Hitchc.

   2. Trophophore mostly arising at or above the middle of the plant, its petiole only to ½ as long as the blade; blade pinnate, the pinnae moderately asymmetrical; pinnae below the apex always lobed; pinna pairs usually more than 5; blade apex somewhat pointed and finely lobed; sporophore with 1–3 main axes and once to twice divided.

      3. Trophophore arising at or below the middle of the plant, the petiole ¼ to ⅓ × as long as blade, blade oblong-deltate to deltate, the basal pinnae 2–2 ½ × as long as the adjacent ones; pinnae coarsely cut, the segments obliquely ovate; upper pinnae and lobes approximate to overlapping; sporophore (so-called "fertile spike") once divided, with only 1 major axis; spores abortive, highly variable (Figure 1A,E; Figure 2B). *B. matricariifolium* × *simplex*

      3. Trophophore arising at or above the middle of the plant, the petiole ⅒ to ⅕ × as long as blade usually; blade oblong, the basal pinnae only slightly larger than the adjacent ones; pinnae mostly finely cut, the lobes linear to wide-oblong, with mostly truncate or truncate-rounded apices; upper pinnae and lobes well separated; sporophore often 2× divided, with 2 or more unequal major axes; spores normal, uniform (Figure 1B,D,F; Figure 2A,C). *B. matricariifolium* A.Br.

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Distribution and Abundance of the Atlantic Walrus, *Odobenus rosmarus rosmarus*, in the Southampton Island — Coats Island Region of Northern Hudson Bay

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A census of Walruses in the Southampton Island — Coats Island region was carried out in the summers of 1976 and 1977. Aerial surveys covered all of the known terrestrial haul-out sites, as well as the ice floes in Fisher and Evans straits and southern Foxe Channel. Observers at a field camp near the main haul-out site on eastern Coats Island provided ground control data and monitored Walrus movements and diurnal changes in Walrus numbers. Maximum numbers of Walruses observed were approximately 1500 on 25 July 1976 and 2400 on 26 July 1977. Disturbances due to weather or human activities caused abandonment of the haul-out site for up to three or four days, particularly if the Walruses had been hauled out for several days prior to the disturbance.

Key Words: Atlantic Walrus, *Odobenus rosmarus rosmarus*, abundance, distribution, behaviour, Canadian Arctic.

In Canadian arctic waters the Atlantic Walrus, *Odobenus rosmarus rosmarus*, ranges from Baffin Bay and Davis Strait, west to about 100 W, including most of Hudson Bay (Loughrey 1959).

Studies on the biology of this species were initiated in Canada in the early 1950s in order to assess the overall status of the population and the effect of apparently wasteful hunting practices caused by the introduction of the rifle into the Inuit economy (Dunbar 1949, 1952). Most investigations have focussed on northern Hudson Bay and Foxe Basin where large numbers of Walruses seek traditional haul-out sites on the land in the summer (Mansfield 1958; Loughrey 1959; Freeman 1974; Miller 1982, 1983).

Estimates of abundance are based largely on aerial surveys carried out during the summer and fall months when Walruses are concentrated at these haul-out sites (Mansfield 1958; Loughrey 1959). All the known haul-out sites in northern Hudson Bay can be surveyed easily in one day, permitting a reasonably accurate count of Walruses to be made. Surveys must take into account temporal fluctuations in haul-out behaviour in order to provide accurate population estimates. Ground control at one or several of the haul-out sites is therefore necessary to monitor daily changes in numbers.

In order to update earlier estimates of abundance and to assess any changes in distribution of Walruses in northern Hudson Bay, aerial surveys were carried out in 1976 and 1977. Local movements and behaviour patterns of Walruses at the main haul-out site on eastern Coats Island were monitored to provide supporting data.

Methods

Aerial surveys were carried out from a twin-engined Piper Aztec aircraft during the periods 24 July - 4 August 1976 and 20 July - 1 August 1977. Flights were made from Coral Harbour over the pack-ice in Fisher and Evans straits and along the coasts of southeastern Southampton Island and Coats Island. The principal haul-out sites in this area and typical flight paths are shown in Figure 1.

Visual estimates of walrus numbers were made from an altitude of 150–250 m and were supported by photographs taken with a hand-held 35 mm camera equipped with a lens of variable focal length (90–230 mm). Inuit hunters, familiar with Walrus' habits in this area, accompanied field personnel on several of the surveys.

Ground observations were made from a camp situated approximately 500 m south of the main haul-out site (62°46′N, 81°56′W) on the east side of Coats Island (*see* Miller 1982, 1983). The camp was occupied from 24 July to 28 August 1976 and from 19 July to 29 August 1977. Most of the Walruses on or near the haul-out site could be readily observed from the camp with a 40 power telescope. Counts were usually made at hourly intervals, up to 10 per day, and were supported by photographs taken with a 35 mm camera equipped with either a 300 mm or 400 mm lens, or a lens of variable focal length (90–230 mm). The portion of the haul-out

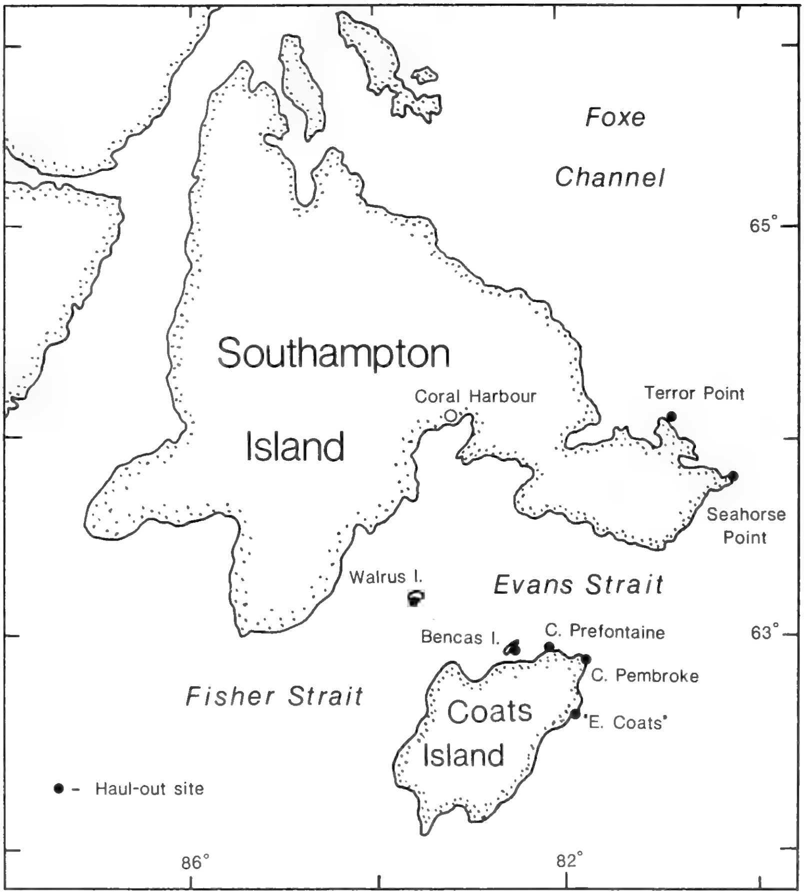

FIGURE 1. Map of Southampton Island and Coats Island showing position of haul-out sites.

site not visible from the camp was observed and photographed from a small inflatable boat. Colour transparencies were later used to provide an estimate of the number of Walruses present. The transparencies were projected onto a 60 × 90 cm sheet of white drawing paper and the number of Walruses counted. Thirty-four transparencies were selected from the large number of photographs taken and read on three separate occasions in random order. The means of each triplicate count were used as the best estimate of numbers observed on each survey day. When photographic documentation was unsuitable or unavailable, visual estimates were used.

Walrus movements to and from the east Coats Island haul-out site were recorded, together with notes on group size and composition. Individual animals were classified according to the following criteria:

adult male	large body, tusk and neck size
adult female	long, slender tusks, neck and head
immature	— tusks less than 15 cm
yearling	— recently erupted tusks
calf	— no tusks visible

Results

Estimates of the numbers of Walruses observed during the aerial surveys are given in Table 1. Maximum numbers observed were approximately 1500 on 25 July 1976 and 2400 on 26 July 1977. For Walrus numbers below 500, linear regression analysis of the pairs of estimates resulting from visual observations and photographs ($n = 17$) shows a small but consistent underestimate of numbers by visual observation ($a = 8$, $b = 0.80$, $r = 0.90$). For numbers above 500 ($n = 6$) correlation between visual and photographic counts is poor ($a = 700$, $b = 0.17$, $r = 0.45$), indicating that visual estimates of these larger groups is unreliable.

The distribution of Walruses was largely determined by the presence and abundance of ice floes in Fisher and Evans straits. This was observed particularly during the 1977 season when large

TABLE 1. Numbers of Walruses observed on or around traditional haul-out sites in northern Hudson Bay from aerial surveys in 1976 and 1977.

Date	Walrus Island	Bencas Island	Cape Préfontaine*	Cape Pembroke*	East Coats*	Sea Ice	Total
1976							
24 July[a]	297[b]	167[b]	0	240[b]	536[b]	-	1230
24[a]	169[b]	0	0	0	561[b]	-	730
25	368[b]	0	33[b]	0	1090[b]	-	1491
26	103[b]	0	102[b]	30	992[b]	-	1227
27	250	0	92[b]	282[b]	773[b]	-	1397
28	75	0	103[b]	345[b]	333[b]	-	856
29	15	15	12	30	175	-	232
30	8	0	75	0	175	-	258
31	9	0	20	0	225	-	254
1 August	7	0	195	0	450	-	652
3	0	0	160[b]	50	536[b]	-	746
4	0	0	7	12	750	-	769
1977							
20 July	0	-	0	0	20	6	26
21	0	-	-	-	-	800	800
22	0	-	-	-	0	300	300
23	25	-	-	-	-	675	700
24	0	-	0	0	6	-	6
26[c]	0	-	25	0	1721[b]	425	2171
26[c]	-	-	-	-	-	625	625
28	0	-	0	13	125	0	138
29	0	-	0	248[b]	179[b]	0	427
1 August	0	-	70	150	1113[b]	0	1333

[a]Two surveys were made on 24 July 1976, a late morning and an early evening flight.
[b]Estimates based on the mean of triplicate counts from photograhs.
[c]Two surveys were made on 26 July 1977, a morning and an afternoon flight. The afternoon count of Walruses on the sea ice was considered in computing the total of 2370 Walruses for that day.
*Cape Préfontaine, northern Coats Island, 62°59′N, 82°16′W.
Cape Pembroke, northeastern Coats Island, 62°57′N, 81°54′W
Main haul-out site, eastern Coats Island, 62°46′N, 81°56′W

numbers of Walruses were present in areas where the ice coverage was approximately 30–50 percent. As the ice disappeared from Evans Strait, the Walruses appeared to abandon this area in favour of the haul-out sites on Coats Island, particularly the main site on the east coast.

Counts made from level at the main site were consistently lower than those made shortly afterwards from the survey aircraft, owing to a proportion of animals being hidden from the observer. Photographs from the ground observation point, taken simultaneously with the visual counts, were analyzed for the 1976 season only. In contrast to counts made from the air, counts from the ground photographs were generally lower than the visual counts, averaging 89 ± 13 percent of the field tally for the total sample.

There were marked fluctuations in the maximum daily numbers of Walruses at the main haul-out site on eastern Coats Island through the course of the summer. Peaks in the numbers of animals generally occurred following a build-up period of two or three days. The number of Walruses remained high for one to three days, and then declined relatively rapidly. During 1976 five peaks were observed at intervals of six to ten days, with a trend towards decreasing numbers in the latter part of August. By contrast, the numbers of Walruses observed in 1977 tended to increase through the middle of August and six peaks were observed at intervals of four to six days. Maximum numbers in 1977b were two to three times those in 1976 (Figure 2). There did not appear to be any trend in haul-out behaviour associated with time of day in either year.

Movements of Walruses to and from the haul-out site were monitored, particularly during the 1976 season. Extensive observations from both land and air on 3–5 August indicated that, once Walruses were hauled out on the land in large numbers, most of those remaining in the water occurred along the coast to the south of the site (88 percent of the number of groups seen, or 92 percent of the total number of individuals). Observational

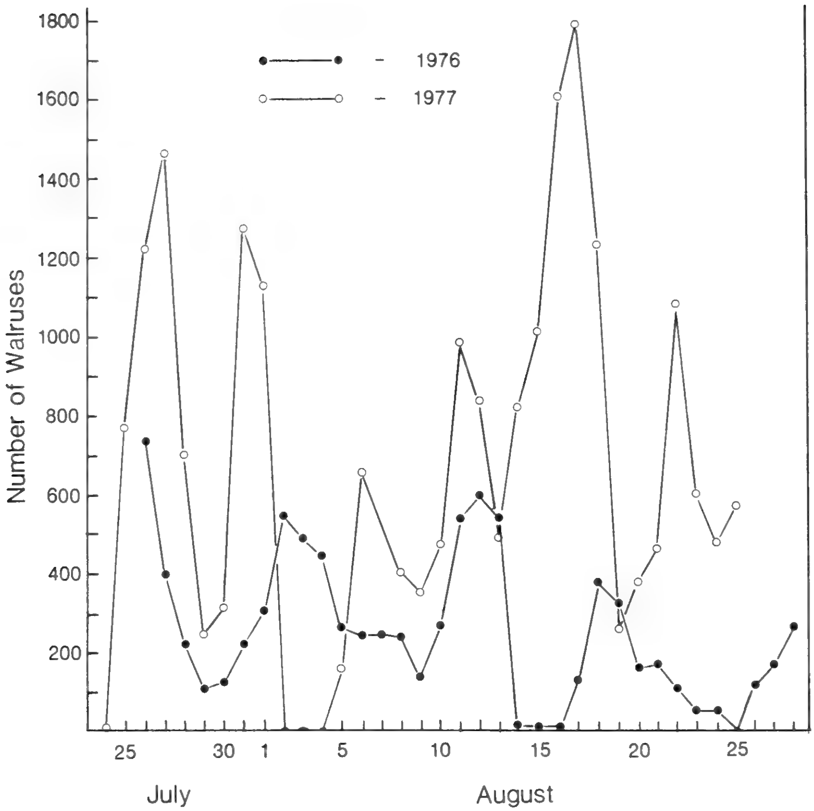

FIGURE 2. Maximum daily numbers of Walruses observed at the main haul-out site on eastern Coats Island in 1976 and 1977.

efforts were therefore intensified to the south of the haul-out site where the groups of animals could be easily and accurately counted and identified as to sex and approximate age. These observations were facilitated by the predictable behaviour of travelling groups, most of which followed the coastline, usually within 100 m of shore, swimming at a steady speed and surfacing at regular intervals.

Information on sex and age composition was compiled from observations made on 12 days during 1976. The groups averaged between four and five Walruses, consisting primarily of adult females, calves and immatures (Table 2). Much larger groups of 15–20 Walruses, which only formed when the haul-out site was abandoned as a result of disturbance, were not included in this

TABLE 2. Sex and age composition of 309 Walrus groups observed swimming along the east coast of Coats Island during the 1976 season.

Classification[1]	No. observed	Mean no. per group	Percent
adult male	199	0.6	14.7
adult female	470	1.5	34.8
immature	273	0.9	20.2
yearling	96	0.3	7.1
calf	225	0.7	16.6
unidentified	88	0.3	6.5
TOTAL	1351	4.4	99.9

[1]See Methods for criteria.

analysis as it was difficult to classify enough of the animals according to sex and age category. These large groups travelled to the south, often breaking up into smaller groups along the way. No larger groups were observed returning to the haul-out site.

The size of the groups is somewhat larger than that observed by Miller (1983) who found the mean size of travelling groups of females and dependent young to be 3.55 (median = 2.69). The difference probably results from our including a number of so-called 'rafting' groups of adult females with nursing young in our analysis, which were observed by Miller to average 5.85 (median = 5.40).

Discussion

Estimates of marine mammal abundance have been made through a variety of techniques, including mark-recapture, catch-per-unit-effort, direct counts, and sampling surveys (Eberhardt et al. 1979). Aerial surveys are particularly useful since a large area can be covered quickly, which reduces the likelihood of resighting animals on any given flight. Observations in the Southampton Island — Coats Island region are facilitated by the Walruses' dependence on specific terrestrial haul-out sites during the open-water season. The most significant limitation of this technique, however, is the unknown proportion of Walruses in the water at the time of the survey (Estes and Gilbert 1978).

The maximum counts of Walruses in 1976 and 1977 were somewhat lower than Loughrey's (1959) estimate of 2900, based on an aerial survey of the known haul-out sites on 20 August 1954. Loughrey believed this estimate to be accurate within 15 percent. One of us (AWM) surveyed the area from a native owned "Peterhead" boat in 1961 and estimated 2100 Walruses at the main haul-out site on Coats Island on 9 August and a further 300 on a small island near Terror Point in Foxe Channel on 20 August. On the assumption that the two herds were separate, this provides a minimum estimate of 2400, similar to our estimate for 1977.

A major difference between the 1976-1977 surveys and those conducted in 1954 and 1961 appears to be in the distribution of Walruses at the various haul-out sites. Whereas about 2000 were observed around Seahorse Point in 1954 (Loughrey 1959), none was observed in this area in 1976 and 1977, probably owing to the proximity of heavy pack-ice along the east coast of Southampton Island. Loughrey had noted that Walruses will abandon the land in favour of ice floes, which tend to curve to the southwest around Seahorse Point in their drift out of Foxe Channel at this time of year (Prinsenberg 1986). This observation is consistent with our count of about 800 Walruses in Evans Strait in July 1977, which were hauled out on ice floes covering about 30–50 percent of the sea surface. The floes were abandoned as they were dispersed by winds and currents and large numbers of Walruses were subsequently observed at the haul-out sites on Coats Island, particularly the main site on the east coast. No Walruses were observed on the heavy ice in Foxe Channel.

During the open-water season, Walruses are greatly affected in their haul-out behaviour by weather conditions and by disturbance from Polar Bears and humans, whether on foot, in boats, or in survey aircraft. When undisturbed by heavy swells breaking on the rocks, Walruses at the eastern Coats Island haul-out site showed a steady increase in numbers over a one to three day period. Adult females and young were most commonly observed in these groups. They generally remained nearer to the periphery of the haul-out site than the adult males, allowing them readier access to the water when danger threatened and lessening the possibility of the young being trampled on and possibly fatally injured if a stampede should occur. These observations at the main haul-out site were subsequently confirmed by Miller (1982) who found that adult females were commonest in the seaward ranks, less common in central locations, and rarest along the inland edges of the herd. This trend was especially pronounced for females with young-of-the-year.

The effect of disturbance depends on several factors including the prevailing weather and the phase of the haul-out cycle; that is, whether numbers are building up, remaining stationary, or declining. It was our impression that when Walruses had been hauled out for several days, or when weather conditions were becoming unfavourable, disturbance of whatever kind generally led to abandonment of the haul-out site and subsequent movement along the coast. The same disturbance occurring during the build-up phase might also result in a mass stampede into the water, but the Walruses tended to remain in the immediate vicinity, hauling out again when the apparent threat no longer existed.

The consequences of prolonged disturbance were not assessed, nor are they easily quantifiable. If haul-out frequency and duration were greatly reduced because of continued disturbance, we might expect stress-associated metabolic imbalances, possibly affecting reproductive success, but there would appear to be little merit in attempting to resolve this issue. The perennial dependence of Walruses on specific feeding and haul-out locations in the Southampton Island – Coats Island region is such that human activities should be kept to a minimum, particularly during the open-water season. The better hunters among the Inuit are well aware of this and restrict their killing

activities to small groups of Walruses well away from the haul-out sites.

For future studies, we recommend that surveys be repeated during the open-water season every four to five years in order to monitor any changes in the distribution and abundance of Walruses in this area. To maximize the benefits of aerial censuses, flights should be made only after two days of fair weather, and at least four days following strong northeasterly to southeasterly winds. The survey crew should also be aware of the distribution and density of ice in Foxe Channel and Fisher and Evans straits, as these are important determinants of the location of hauled-out Walruses. A possible alternative to aerial surveys is the use of unmanned observation stations at the haul-out sites, each equipped for time-lapse photography, but the logistics for servicing such an operation and the protection of valuable equipment from marauding Polar Bears might render such a project impracticable.

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Notes

Elk, *Cervus elaphus*, Calves as Food for Grizzly Bears, *Ursus arctos*, in Banff National Park, Alberta

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Hamer, David, and Stephen Herrero. 1991. Elk, *Cervus elaphus,* calves as food for Grizzly Bears, *Ursus arctos*, in Banff National Park, Alberta. Canadian Field-Naturalist 105(1): 101–103.

During a five-year study of Grizzly Bears (*Ursus arctos*) in Banff National Park, bear activity during late May — early June was partly associated with Elk (*Cervus elaphus*) calves. Either searching behaviour, predation, or location at a carcass was observed in 36% of 33 classifiable Grizzly Bear sightings made between 31 May and 17 June 1976-1980.

Key Words: Elk, *Cervus elaphus*, Grizzly Bear, *Ursus arctos,* Banff National Park, Alberta, calf, predation, hunting behaviour.

Bears can be significant predators of young ungulates. Ballard et al. (1981) determined that Brown Bear predation was responsible for 79% of the 66 natural deaths of 120 Moose (*Alces alces*) calves that were radiotracked in southcentral Alaska. Schlegel (1976) found that in northcentral Idaho total Elk calf mortality was 68% for 58 radio-collared calves. Black Bears (*Ursus americanus*) were responsible for 94% of the mortality.

During a five-year study of Grizzly Bears in Banff National Park (Hamer 1985; Hamer and Herrero 1987), we observed Grizzly Bears killing and possibly scavenging Elk calves within a brief period (late May through mid June) when calves evidently were available to bears. Because the subalpine zone of our study area included extensive dry meadow slopes, we were able to observe hunting behaviour and predation. We report these observations here.

Study Area

The study area occupied about 250 km^2 in the eastern slopes of Banff National Park, within the Front Ranges of the Rocky Mountains. The continental divide was 45 km to the west.

The Front Ranges are separated from the Pacific Ocean by the Coastal and Columbian mountains and by the Main Ranges of the Rocky Mountains. The climate is essentially continental. Portions of the main valleys are semiarid (< 50 cm precipitation/year) (Janz and Storr 1977: 325). This rainshadow effect is exacerbated by the drying effect of the warm, westerly, foehn (chinook) winds that characterise the Rocky Mountains east of the continental divide. Many SE- through W-facing slopes below treeline are forest-free, in part because of the combined influence of low precipitation and strong chinook wind. The study area has abundant Elk (Holroyd and Van Tighem 1983: 636). The largest group of Elk we saw contained 114 animals (31 July 1979); Holroyd and Van Tighem (1983: 494) counted 149 Elk in our study area during a roadside survey (29 November 1979). Other population data are unavailable. Elk occurred throughout the study area, and no specific "calving areas" were known or suspected.

Methods

Data were collected by examining Grizzly Bear feeding sites and, when possible, observing bears directly with 20-45 power telescopes. Feces were collected and analyzed to determine food items. During the last three years of study, 1978-1980, two female Grizzly Bears were radio-tracked.

Recognition of Grizzly Bear feces and signs was greatly simplified by the absence of Black Bears in the study area (Hamer et al. 1981). In addition, an abundance of open meadows and low-stature shrubfields (< 1 m tall) facilitated direct observation of bears.

Results and Discussion

Nine instances of Grizzly Bears hunting or scavenging Elk calves were observed. Our earliest and latest observations were 31 May (1977) and 17 June (1978), respectively.

We saw Grizzly Bears kill Elk calves on four occasions. In the five other cases, we could not determine whether the calf had been killed or scavenged. The two radio-collared bears were responsible for two of the four cases where

predation was observed, and for two of the five cases where either scavenging or predation occurred.

Additional Elk calves could have been killed but escaped detection due to our study methods. First, wide-ranging movements of the two radio-collared bears during early June hampered relocation efforts. Second, the signs associated with calf kills were few, and were localized to areas as small as a few square metres. In all our field checks of suspected kill sites where a sighting had not been made to allow the precise spot to be located, signs of bear activity were found only once.

In two of four cases where predation was observed, the two bears were observed searching for 35 and 55 min, respectively, before each bear located and killed a calf. These bears moved circuitously, often convolutedly, at a pace that was more rapid than the normal walk. The bears sniffed the ground or air repeatedly, and did not feed on vegetation. At least five different single Grizzly Bears or groups exhibited this distinct searching behaviour during 1976-1980. These bears included at least one adult male, a pair of subadults, and three different adult females, variously accompanied by cubs of the year (two different family groups), one-year-old cubs (1), and two-year-old cubs (1).

During the 55-minute search, an adult female Elk repeatedly approached the Grizzly Bear family. Six close approaches (20-40 m) drew the adult female Grizzly Bear away from the Elk calf three times, drew one of the two one-year-old cubs away twice, and had no observable effect once. Eventually the adult bear discovered and picked up the calf from where it lay on a dry meadow slope; the adult Elk was about 20 m away at this time.

During two other incidents, Elk calves were seen to run at least 100 m and at least 300 m. In both cases, the calf ran as fast as or faster than the adult female Grizzly Bear that was in pursuit. In the shorter chase, the calf slipped and then rolled and slid about 50-60 m down steep meadow/colluvium. Before the calf could stand the bear reached the calf, bit its neck, shook it, and killed it. In the longer chase, the calf increased the separation between itself and the bear from about 5 m to over 60 m. With the bear still in pursuit, the calf joined an adult female Elk and trotted into dry shrubland littered with deadfall from a 1936 wildfire. Perhaps because of the more difficult travelling conditions caused by the deadfall, the calf apparently was soon caught by the bear, since, after we re-positioned ourselves, we next saw the family of Grizzly Bears feeding on an Elk calf about 100 m from where the Elk had last been seen.

One adult female Grizzly Bear with two cubs of the year did not seem to hunt Elk calves, even when a young calf (< 1 day old) was seen on the same slope 500 m away (1 June 1980). Other calves also ranged in this area. On 7 June 1980, a radio-collared bear killed a calf on these open slopes, approximately 1800 m from where the unmarked bear and her two cubs were grazing at the same time. This unmarked female was seen on nine different days during 31 May-12 June, for a total of 29 hours of observations, and never once did she exhibit the searching behaviour shown by bears hunting Elk calves.

Of all relevant sightings between 31 May and 17 June, 1976-1980, searching behaviour or location at a carcass was observed in 12 of 33 sightings (36%). These 33 sightings included the nine sightings of the unmarked female described in the above paragraph. (The 33 sightings excluded observations of bears engaged in mating activity [N = 7] and brief sightings where the observation lasted less than 5 minutes because the bear fled, walked quickly out of view, or was seen only momentarily from a helicopter [N = 6]).

We lacked quantitative data concerning either the Elk or Grizzly Bear populations and so mortality levels could not be determined. Our observations do document well-developed, successful Grizzly Bear hunting for Elk calves, suggesting that this could be an important source of mortality.

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Overwinter Survival of Orphan Caribou, *Rangifer tarandus*, Calves

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Eight orphan calves from the Porcupine Caribou Herd were radio-collared in September and November of 1987. Subsequent tracking revealed that five of the eight survived to the next calving period (June 1988). This compared with 94 of 120 non-orphan calves surviving over a similar time period although in different years (1983-1985). Survival of orphans was not significantly different from survival of non-orphans. The results of this study have implications for managers assessing the impact of harvesting productive females in the fall.

Key Words: *Rangifer tarandus*, Caribou, calf, mortality, survival.

The maternal bond in Caribou usually remains intact through the calves' first winter (Russell unpublished observation). The survival value for the calf of maintaining the bond may be related to the sharing of feeding craters, direct nourishment from milk, and/or protection from predators. The objective of this study was to examine the survival of calves orphaned in the fall when the maternal bond was still intact, but after lactation in the female had greatly diminished (White and Luick 1984).

In the fall of 1987, we attached radio-collars to the calves of eight females collected for a study of body condition for the herd. Four collars were attached in September, on the Porcupine River, Yukon, at the initiation of fall migration and four were attached in November, 100 km southeast of Old Crow, Yukon, at the onset of winter. The September calves were physically restrained while attempting to cross a river and the November calves were captured with a net gun from a helicopter (Barrett et al. 1982). The collars were monitored four times subsequent to capture (October, November, April, June) and those with mortality signals retrieved.

From capture to the following calving period (June), three calves died (Table 1). The cause of death was not determined as relocations were too infrequent and collars had to be retrieved from under the snow. In all cases, however, the carcass was scattered and had been either killed or scavenged by predators.

The U.S. Fish and Wildlife Service and the Alaska Department of Fish and Game conducted a study from 1983-1985 on the mortality of calves in the Porcupine Caribou Herd. Their unpublished figures indicate that 26 of 120 non-orphan calves died from September to the following calving period. Two conditions were different than the present study. First the orphan calves overwintered in a year of deep snow and second, we could not account for any capture induced mortality in

TABLE 1. Summary of data on orphaned calves of the Porcupine Caribou Herd.

Calf	Date of capture	Location lat	long	Sex	Weight[1] (kg)	Fate of calf	Date Death Detected
OC1	Sept. 87	67°28′	140°35′	F	36.8	survived	—
OC2	Sept. 87	67°28′	140°35′	M	47.7	died	24 March 1988
OC3	Sept. 87	67°28′	140°35′	F	34.1	survived	—
OC4	Sept. 87	67°28′	140°35′	F	45.5	died	25 March 1988
EP1	Nov. 87	66°25′	136°30′	M	53.2	died	6 April 1988
EP2	Nov. 87	66°25′	136°30′	F	52.3	survived	—
EP3	Nov. 87	66°25′	136°30′	F	53.2	survived	—
EP4	Nov. 87	66°25′	136°30′	F	54.5	survived	—

[1]Body weight at capture.

the orphan sample. In the non-orphan sample, collared in June, capture induced mortality would likely not be a factor after September.

Using the two data sets in a 2 × 2 contingency table (Zar 1974), we determined that the mortality of orphan calves in our study was not significantly different from the mortality of non-orphan calves ($\chi^2 = 0.36$).

Members of the Porcupine Caribou Herd dig feeding craters through snow to obtain their principal winter food source, fruticose lichens (Kelsall and Klein 1979; Russell and Martell 1984). Digging of craters may occur as early as mid October for this herd. For *Rangifer*, in years of adverse snow conditions, a distinct social hierarchy has been documented with antlered females having the highest rank from mid to late winter (Thompson 1977; Shea 1979). The accompanying calves of these productive females benefit from their mothers' high status by sharing feeding craters dug by the mother or craters taken over by the mother in displacing lower ranked individuals (Shea 1979). The energetic advantage to the calf by accompanying its mother is assumed to be significant due to the energy cost of digging food craters (Fancy and White 1985).

Nursing bouts among Caribou in the fall are so infrequent (two to four times daily from September to October, R. G. White and K. C. Parker, unpublished observation) that the direct advantage of mother's milk is not considered nutritionally critical (Butler 1983).

Lone calves, separated from aggregations during insect harassment, are often preyed upon during the summer months (D. E. Russell and W. A. Nixon, unpublished observation) but little evidence is available if a comparable situation occurs in the winter. We assume that antlered females could offer protection for their calves until the maternal bond breaks.

Our data indicated that these factors, which may benefit the survival of a calf accompanying its mother, did not result in a measurable increase in overwinter mortality to orphan calves. These results can be used in our estimate of sustainable harvest in the herd. Ninety percent of the Caribou harvested from the herd are taken by native communities in Alaska, Yukon and the Northwest Territories. Most of this harvest occurs in the fall and early winter and a significant proportion of this harvest is productive females. Therefore orphaning in September to November in this herd may be primarily induced by hunting. This study suggests that the calves of females harvested in the fall are not subjected to higher mortality than non-orphan calves.

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Observation of Barren-ground Grizzly Bear, *Ursus arctos*, Predation on Muskoxen, *Ovibos moschatus*, in the Northwest Territories

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Observations of Grizzly Bears (*Ursus arctos*) killing and feeding on Muskoxen (*Ovibos moschatus*) are rare. We observed a bear feeding on a Muskox bull in May 1987 near Coppermine, Northwest Territories. The state of the carcass and tracks in snow allowed us to reconstruct the sequence of the bear killing the Muskox. We also recorded two other possible instances of Grizzly Bear predation on Muskoxen.

Key Words: Grizzly Bear, Predation, Muskox, Northwest Territories.

Barren-ground Grizzly Bears (*Ursus arctos*) and Muskoxen (*Ovibos moschatus*) both inhabit most of the mainland tundra in the Northwest Territories (N.W.T.). However, few interactions have been documented between Grizzly Bears and Muskoxen despite their range overlap. Gunn and Miller (1982) documented a Grizzly Bear preying on an adult bull Muskox in the Thelon Game Sanctuary, N.W.T., and also cite several other reports of Grizzly Bears feeding on Muskox carcasses. During an aerial survey Heard (personal communication) observed a Grizzly Bear harassing a Muskox herd in the Queen Maud Gulf area but the aircraft's presence chased the bear from the area. There are no reported observations of a bear actually attacking and killing a Muskox.

During a preliminary investigation into Grizzly Bear abundance in the valley of the Rae and Richardson rivers west of Coppermine on 8 May 1987, the authors observed a Grizzly Bear feeding on a Muskox carcass at approximately 67°57′30″N 117°58′00″W. The bear ran from the carcass with the approach of the helicopter.

The Muskox was an adult bull at least five years old as tooth eruption was complete with no discernable wear and the horn boss met completely (Olesen and Thing 1989). We did not measure or weigh the bull; however, based on weights for mainland Muskox (Gunn 1982) the bull probably weighed in excess of 300 kg. The Muskox was in excellent condition with extensive subcutaneous fat and firm white femoral marrow.

The exact manner of death could not be determined but the bear had apparently attacked and killed the Muskox from behind. The only lacerations found were on the Muskox's back and the back of the neck. There was no damage to the head, throat or muzzle of the Muskox unlike Gunn and Miller's (1982) description of Grizzly Bear predation on a Muskox.

The kill was less than 18-hours old as snow had fallen in the area 18 hours previously and the tracks were more recent. In addition, the Muskox meat was not frozen, even in areas where the hide had been removed. The temperature in Coppermine the morning of 8 May was -18°C.

We determined the details of the kill by following the tracks in the snow. The bear had followed a group of four bull Muskoxen for approximately 5 km. The bear travelled parallel to the herd and slowly closed to within 40 to 50 m of the Muskoxen then charged directly towards them. When the bear charged, the Muskoxen ran but broke through the crusty snow and floundered. The bear also broke through the crust but was powerful enough to force its way through and catch up to one of the Muskoxen.

Snow conditions were important in the success of the kill. The snow was about 75 cm deep with a firm crust on top which would, in most areas, support the authors. The crust overlaid a thick layer of coarse granular snow which would not support any weight.

The remaining three bulls of the herd were seen about 5 km northwest of the kill site two days later. The kill site was checked five times over the 17 days following the kill. During this period the bear utilized the carcass extensively and was seen within 5 km of the carcass on two of five checks of the kill site. On the final visit, on 25 May, only the skull, hair, lower legs and bone fragments remained.

Grizzly Bears were found to have visited two other Muskox carcasses, an adult male and an adult female, along the Rae and Richardson rivers during May. These Muskoxen had apparently died earlier in the spring as the connective tissue on the bones was frozen not dried. Both carcasses were almost completely disassembled with small pieces of hide and the larger bones such as the leg bones, vertebrae and the skull scattered over at least a 5 m radius. The marrow from the long bones (femur or humerus) of both Muskoxen was firm and slightly pinkish indicating mild nutritional stress. The carcass of the adult male had been visited by a different bear than the one that we observed on the fresh kill.

As there was no evidence of Wolves (*Canis lupus*), the only other predator on Muskox in the area, and the dead Muskoxen appeared to be in good condition, the three carcasses observed were probably killed by Grizzly Bears. The observation that Grizzly Bears prey on adult Muskox suggests that the bears should also be able to prey on calf Muskoxen. Evidence of predation on calves would be difficult to obtain as it likely that the bears would consume the entire carcass. Grizzly Bears could, therefore, be a significant cause of Muskox mortality.

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First Records of the Bering Wolffish, *Anarhichas orientalis*, for the Alaskan Beaufort Sea

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Fruge, Douglas J., and David W. Wiswar. 1991. First records of the Bering Wolffish, *Anarhichas orientalis*, for the Alaskan Beaufort Sea. Canadian Field-Naturalist 105(1): 107–109.

The first recorded captures of Bering Wolffish, *Anarhichas orientalis*, in the Alaska Beaufort Sea are reported. Three immature individuals of the Bering Wolffish were taken by fyke net on 19 July, 8 August, and 15 August 1987 in Camden Bay on the northeast Alaskan coast. Two of the Bering Wolffish were preserved as reference specimens.

Key Words: Bering Wolffish, *Anarhichas orientalis*, new records, Alaska, Beaufort Sea.

The Bering Wolffish, *Anarhichas orientalis* (Anarhichadidae), has been described as being distributed in the northwestern Pacific Ocean from Hokkaido and Shikotan Island to eastern Kamchatka and the Sea of Okhotsk (Barsukov 1959). Barsukov (1959) stated that in Alaskan waters Bering Wolffish are common in "Norton Bay" and that they have been found in the Pribilof and Commander Islands as well.

Although the Bering Wolffish has been confirmed from the Bathurst Inlet area of northern Canada (Hunter et al. 1984), there have been no reports from the Alaskan Beaufort or Chukchi Seas, a considerable hiatus (over 2700 km) in the known distribution of the species. Quast and Hall (1972) did not list any reports for this species north of the Bering Sea. In a comprehensive review of coastal fish use of the Beaufort Sea, Craig (1984) made no mention of the family Anarhichadidae, nor were any wolffishes found in a trawl survey of the eastern Chukchi and western Beaufort Seas in 1976 and 1977 (Frost and Lowry 1984). A fish tentatively identified as Northern Wolffish (*Anarhichas denticulatus*) was reported by Smith (1977) in the Amundsen Gulf area, though it is possible that this fish could have been a Bering Wolffish since identification was based on a photograph of a carcass.

Three individuals of this species were captured by fyke net in water depths of 1.2 meters during the summer of 1987 in the Camden Bay area of the Alaskan Beaufort Sea coast and provide first known records of the species in the Alaskan portion of the Beaufort Sea. Two of the Bering Wolffish were captured in the Simpson Cove (69° 57′ N; 144° 54′ W) (Orth 1967) area of Camden Bay on 19 July and 15 August 1987. The site (Station SC02) is located on the south shore of a spit just east of a barrier island known as Collinson Point (Figure 1). Another Bering Wolffish was caught on 8 August 1987 at an open coastal location (Station KP01) (Figure 1) approximately 3.5 km west of the mouth of the Katakturuk River and 4.9 km southeast of Konganevik Point (70° 01′ 30″ N, 145° 10′ 30″ W) (Orth 1967). The substrate at both sample sites was gravel and sand.

Salinity and temperature recorded at the surface and bottom during the time the nets were checked indicated the water column was not stratified. Salinity and temperature at Station SC02 were $25^{0}/_{00}$ [parts per thousand] and 4° C on 19 July and $19^{0}/_{00}$ and 13° C on 15 August. On 8 August salinity and temperature were $25^{0}/_{00}$ and 8° C at Station KP01.

Two specimens were initially preserved in formalin and are currently stored in the fish reference collection of the U.S. Fish and Wildlife Service, Fairbanks Fishery Assistance Office (catalog numbers 118 and 175). The third individual was released.

Total lengths (straight line distance from anteriormost part of head to tip of caudal fin) of the three fish were measured using a fish measuring board at the time of collection. These total length measurements were: 171 mm (SC02, 19 July); 175 mm (SC02, 15 August); and 182 mm (KP01). The following measurements (in millimeters) were made on the two preserved specimens. Data for the SC02 specimen precede data for the KP01 specimen in the series of paired measurements. Total length 158; 165. Standard length (straight-line distance from anteriormost part of head to base of of caudal rays): 142; 152. The remaining measurements are also presented as proportions (per cent of standard length) in parentheses. Preanal length (straight-line distance from anteriormost part of head to posterior margin of anus): 65 (46%); 73 (48%). Predorsal length (straight-line distance from tip of snout to first dorsal fin ray): 28 (20%); 31 (20%). Head length (straight-line distance between tip of snout and posteriormost part of opercle); 33 (23%); 34 (22%).

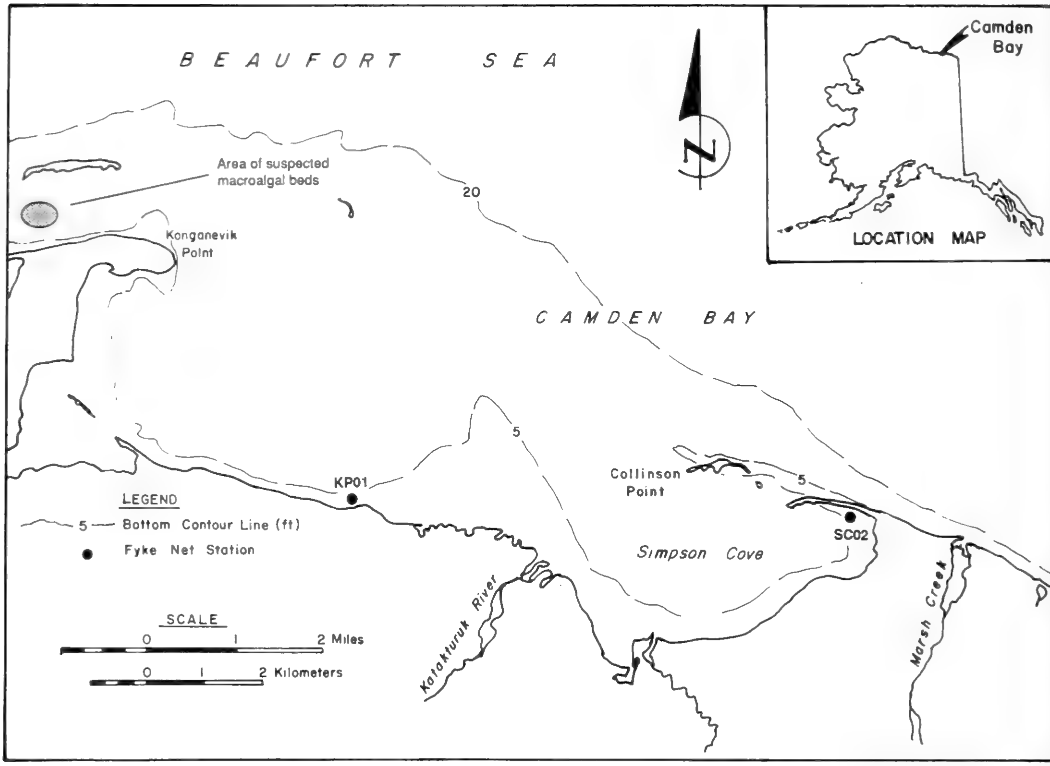

FIGURE 1. Locations in Camden Bay, Alaskan Beaufort Sea, where Bering Wolffish, *Anarhichas orientalis*, were collected in July and August 1987.

Body depth (greatest straight-line distance, measured perpendicular to vertebral axis, between base of dorsal fin and ventrum, exclusive of fins): 30 (21%); 30 (20%). Dorsal fin origin to upper border of gill slits (straight-line distance between first dorsal fin ray and dorsalmost margin of gill opening): 10 (7%); 13 (9%). Fin ray counts on the preserved specimens are: dorsal 85, 85; anal 53, 53; caudal 23, 24; pectoral 21, 21.

Color patterns of the two preserved specimens are similar. The entire head is mottled with dark brown spots approximately equal in size to the pupil diameter; some adjacent spots are confluent. The spots occur on a greyish to yellowish-white background. Four or five horizontal dark brown stripes occur on the sides of the body against a similar yellowish-white background. The stripes appear to be formed from confluent spots and vary in width from approximately equal to the pupil diameter to about the orbit diameter. Two similar light brown horizontal stripes appear on the dorsal fin. An indistinct horizontal light brown stripe occurs near the margin of the anal fin, and a similarly-colored indistinct stripe occurs near the margin of the pectoral fins parallel to the curvature of the fin margin. The margins of all fins are similar to the light body background color.

The rows of vomerine teeth are noticeably longer than the tooth rows on the palatines, conforming with descriptions given by Barsukov (1959) for Bering Wolffish. This characteristic along with the dorsal fin count and coloration, particularly the horizontal dark stripes on the sides of the body, are diagnostic according to Barsukov (1959), and from these characteristics we concluded that our specimens are *Anarhichas orientalis*.

The preserved specimens do not exhibit any gonadal development and are assumed to be immature. Barsukov (1959) reports a Bering Wolffish 150 mm long as "a yearling."

Andriayashev (1954) stated that the Bering Wolffish is "the most shallow-water species of the genus *Anarhichas*," inhabiting stone substrate overgrown with algae. Barsukov (1959), also reported that the species inhabits coastal stony reefs covered with vegetation. If this is the case, in the Alaskan Beaufort Sea the Bering Wolffish may be associated with stony outcroppings harboring macroalgal (brown kelp) beds and unique

assemblages of benthic invertebrates. The largest of these outcroppings is known as the "Boulder Patch", located in Stefansson Sound, about 85 km west of the Camden Bay area. A similar macrophyte bed is suspected to exist just west of Konganevik Point in western Camden Bay (Dunton et al. 1982), approximately 10 and 20 km west of our sampling stations KP01 and SC02, respectively (Figure 1). Pieces of brown kelp are commonly found washed ashore in Camden Bay.

Bering Wolffish were not reported as a result of diver observations and epilithic scrape collections in the Steffanson Sound Boulder Patch (Dunton et al. 1982), nor has intensive sampling by fyke net since the mid-1970s in the nearby Prudhoe Bay area yielded Bering Wolffish. Since the Steffanson Sound Boulder Patch is located in an area directly influenced by the freshwater plume of the Sagavanirktok River, habitat conditions may be less favorable for the Bering Wolffish there than in Camden Bay.

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An Observation of a Wild Weasel, *Mustela erminea*, Moving Its Pups

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Packard, Jane M., and L. David Mech. 1991. An observation of wild weasel, *Mustela erminea*, moving its pups. Canadian Field-Naturalist 105(1): 110–111.

Although the reproductive behavior of weasels has been studied in captivity and movements have been studied at lower latitudes, little is known about reproduction of weasels in the high arctic. We observed a den near a tundra stream. A litter of four, apparently born in May, was full size by the end of the growing season, Notable behaviors of the adult included retrieval of a cached lemming, leading pups from one rockpile to another carrying the lemming, and carrying a pup in the mouth. The short growing season of the arctic may explain why *M. erminea* has only one litter per season in contrast to *M. nivalis*.

Key Words: Weasel, *Mustela erminea,* ermine, reproduction, arctic.

Although much attention has been given recently to the reproduction strategies and behavioral ecology of weasel species (Erlinge 1983; King 1984; Sandell 1984; Powell 1985; Stenseth 1985), relatively little information has been reported regarding their reproductive behavior in the wild. We had an opportunity to observe the denning behavior of a female ermine or stoat (*Mustela erminea*) on Ellesmere Island, North West Territories, 80° N latitude.

Denning behavior of weasels in the Arctic is relevant to interpreting the evolution of reproductive strategies. The short summer growing season at high latitudes may represent conditions more widespread when the various reproductive strategies evolved. A short growing season would favor the adaptations characteristic of *M. erminea* (single litter, delayed implantation and delayed maturity) over that of species that have multiple litters during one season (e.g. *M. nivalis*). Most studies of weasels (e.g. Simms 1979b; Erlinge 1983) have been done at lower latitudes, and therefore did not include the effects of a shorter season. Simms (1979a) emphasized the dramatic difference in number of days with snow cover in New York (90-120 d) and the high arctic (240+ d).

The den we observed was located in a rockpile on a ridge intersected by a stream banked by about 1 m of grassy vegetation and slopes of heather hummocks. Den sites previously reported for stoats included those situated in bogs and meadows along streams (Simms 1979a) and marshes or stone walls in farmland (Erlinge 1977). Other weasel species denned in burrows, tree roots and farm buildings (Bishop 1923; Criddle and Criddle 1925; Ingles 1942; Hall 1951).

In response to a human standing silently or squeaking near the Ellesmere den, the female weasel came within 1 m, flitted from one rock to another and chattered. One of the four young appeared at the entrance to the den but did not come out. The boldness of adult weasels in approaching humans has also been reported by Soper (1919). Potential predators in the area include Wolves (*Canis lupus*), Arctic Foxes (*Alopex lagopus*), Snowy Owls (*Nyctea scandiaca*) and possibly Gyrfalcons (*Falco rusticolus*). Although Wolves sniffed around the den, we did not see evidence of attempts to catch the weasels.

Judging by the adult size of the young, the weasel litter was probably 80-100 d of age. East and Lockie (1965) reported close-to-adult weights for captive-reared ermine of that age. As our observations were made in the last week of July (1988), birth probably occurred by the first of May, unless we misjudged the age. In the British Isles, Deansley (1944) documented that birth occurred by May. In August, mean daily temperature on Ellesmere begins to decline, and vegetation passes its peak in growth.

Caching behavior is one of the adaptations providing a buffer against fluctuating food supplies in a low-productivity and risky environment. We observed the weasel take a small rodent carcass from holes adjacent to the den on three separate days. The lemming (*Dicrostonyx groenlandicus*), is the only rodent on Ellesmere. Because the carcass(es) appeared desiccated, we judged that it (they) had been deposited some days before. Caching in weasels was reported by Criddle and Criddle (1925).

On one occasion, the weasel carried a carcass while leading the pups from one rockpile to another when disturbed by a human. The female carried the lemming carcass from one hole to another twice, then ran carrying it toward another

rockpile about 3 m distant. One pup followed her at once, while three others joined her later. The four pups dashed in and out of holes at the second rockpile. In the confusion, the female picked up a pup, lifting it off the ground with her mouth and carried it back to the first rock pile. Pup-carrying by a female after a nest disturbance has been reported for captive *M. nivalis* (East and Lockie, 1964), but we know of no similar reports from the wild or for *M. erminea*.

In the situation we observed, the pup-moving appeared maladaptive because the young could have been captured by a predator. However, pup-moving may be an adaptive response to disturbance of a den by events such as a rock slide. In the post-glacial environment, rock slides may have been a more frequent occurrence than is typical of stabilized substrates in current environments. The high latitude current environment may more closely resemble the environment to which the progenitors of weasels were adapted, in comparison to the lower latitudes in which the species have been studied.

Acknowledgments

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Deadly Nightshade, *Atropa belladonna* (Solanaceae), in Newfoundland

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Scott, Peter J. 1991. Deadly Nightshade, *Atropa belladonna* (Solanaceae), in Newfoundland. Canadian Field-Naturalist 105(1): 112.

A colony of Deadly Nightshade has become established in St. John's on the campus of Memorial University and has been monitored since 1982, and is not spreading. This is the first Canadian record.

Key Words: Deadly Nightshade, *Atropa belladonna,* Solanaceae, Newfoundland.

Atropa belladonna L. (Solanaceae), Deadly Nightshade, is a native of south central Europe, western Asia, and northern Africa (Clapham et al.1987 and Tutin et al. 1972). In 1982 a colony was found in St. John's, Newfoundland. The plants were growing in a south-facing alcove of a building on the campus of Memorial University of Newfoundland. The colony has been monitored and has remained in good condition with the addition of several young plants. There are currently three clumps that are rooted by the wall of the building which further enhances the conditions within their microhabitat. The plants flower and fruit prolifically each year.

This species has not been recorded previously for Canada (Scoggan 1978; Boivin 1966) or for most of the United States; however, Cronquist (*in* Hitchcock et al. 1959: part 4, page 282) reports that it is "occasionally found as a weed in our range west of the Cascades". Neither the National Herbarium, Canadian Museum of Nature (CAN) [A. Dugal, personal communication, 1988] nor the herbarium of the Biosystematics Research Centre, Agriculture Canada (DAO) [W. J. Cody, personal communication] contain any specimens from North America.

The presence of *A. belladonna* in Newfoundland may be explained by an introduction with nursery stock since shrubs imported from the Netherlands were held in an area ten metres from the present stand. Other reports of Deadly Nightshade on the island of Newfoundland have all proven to be *Solanum dulcamara* L. *A. belladonna* is established but is not spreading, an advantage for the local populace since the lustrous black fruit which look very appealing are extremely poisonous, containing the alkaloid atropine (Kingsbury 1964).

A voucher specimen is deposited in the Ayre Herbarium, Memorial University of Newfoundland (NFLD.)

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Competition for Cavities among Great Crested Flycatchers, *Myiarchus crinitus*, Northern Flickers, *Colaptes auratus*, and Tree Swallows, *Tachycineta bicolor*

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Rendell, Wallace B., and Raleigh J. Robertson. 1991. Competition for cavities among Great Crested Flycatchers, *Myiarchus crinitus*, Northern Flickers, *Colaptes auratus*, and Tree Swallows, *Tachycineta bicolor*. Canadian Field-Naturalist 105(1): 113–114.

We observed incidents of aggressive conflict for cavities between Great Crested Flycatchers, *Myiarchus crinitus*, and Tree Swallows, *Tachycineta bicolor*, and Northern Flickers, *Colaptes auratus*, and Tree Swallows. Also, circumstantial evidence suggests that flickers may remove clutches from cavities belonging to Tree Swallows and enlarge these cavities for their own use. These observations provide additional insight into the importance of competition as a factor influencing cavity availability for hole-nesters.

Key Words: Great Crested Flycatchers, *Myiarchus crinitus*, Northern Flickers, *Colaptes auratus*, Tree Swallows, *Tachycineta bicolor*, interspecific competition, cavities.

We describe observations of interspecific competition for natural cavities between Great Crested Flycatchers, *Myiarchus crinitus*, and Tree Swallows, *Tachycineta bicolor*, and also between Northern Flickers, *Colaptes auratus*, and Tree Swallows. Although intraspecific (e.g., Robertson et al. 1986; Stutchbury and Robertson 1987) and interspecific (e.g., Erskine 1964; Ingold 1989; Kerpez and Smith 1990) competition for limited nesting cavities is widely documented, the incidents described herein are unique to the literature. Observations were made at Allan's Pond, a beaver pond with 200-300 standing snags near the Queen's University Biological Station, Chaffeys Locks, southeastern Ontario (44° 30′ N; 76° 23′ W). [See Rendell and Robertson (1989) for a more complete description of this study site.]

In May 1987, a pair of Great Crested Flycatchers usurped a nest-site from a pair of Tree Swallows that had been defending the cavity, but not nesting in it. Tree Swallows often defend one or two extra cavities that are near their primary nest-site (Rendell and Robertson 1989). During behavioural watches, the pair of swallows had been seen defending both the contested cavity (#001) and their primary nest (#059, 25 m SW of #001) from conspecifics since 1 May. The swallows were incubating eggs when two Great Crested Flycatchers were first seen visiting cavity #001 on 21 May. On three occasions from 21 May-26 May, we observed both flycatchers perching at and entering cavity #001. They were not carrying nest material, nor were they confronted by the pair of Tree Swallows. On 28 May, however, while one flycatcher was inside cavity #001, the resident male swallow from #059 (AHY; female was SY) alternately circled #001 giving alarm calls and perched at the entrance, from 07:40 to 08:40. The male Tree Swallow retreated to perch near #059, and then returned to "harass" the flycatcher throughout the hour. At 08:50, the second flycatcher perched at the cavity entrance of #001 as the other departed the cavity. The male Tree Swallow immediately made repeated dives at the perched flycatcher while giving alarm calls, and eventually struck the flycatcher on the back. The flycatcher remained perched at the hole while the swallow circled the snag and hovered near the entrance. After a short time (ca. 5 min.), the Tree Swallow retreated to perch near #059 and was not observed near the flycatchers again. The latter subsequently nested in #001 and were last seen on 20 June.

In another case of interspecific conflict, a Northern Flicker was evicted from its cavity by a pair of Tree Swallows. On 13 May 1987, we observed a flicker excavating a new cavity (#067) near several occupied swallow nest-sites. At 11:00 on 15 May, however, the resident Tree Swallows from #017 (ca. 45 m NE of #067) harassed the flicker while it excavated, chattering and diving at the bird, and perching on the flicker's snag. The Tree Swallow pair had abandoned their cavity and partial clutch on 6 May when we banded and color-marked the female during egg-laying. On 17 May, the same pair continued to harass the flicker. In this instance, the flicker watched the swallows constantly, avoiding their close dives by moving around the trunk of the snag. At 08:50 the flicker departed and was not observed near #067 again. The female swallow immediately began carrying nesting material from the shore of the pond to the cavity and continued to do so throughout the morning. This Tree Swallow pair

successfully fledged young from #067 in the last week of June.

On the same day the flicker was evicted from #067, a flicker began excavating a new cavity approximately 30 m N of #067. Construction of the new cavity (#070) presumably continued until 21 May when a pair of Tree Swallows was observed occupying the new cavity. The male (AHY) was perched 10 m from the nest-site while the female (SY) moved in and out of the cavity. No aggressive interactions between the flicker and swallows had been observed, but is seems likely a flicker was evicted again. This same pair of swallows was seen copulating at #070 on 25 May, but subsequently abandoned the nest-site before 28 May.

Circumstantial evidence suggests that flickers may compete for nest-sites with Tree Swallows by removing eggs from cavities belonging to swallows, and then by subsequently enlarging the usurped cavity for their own nesting purposes. On two occasions in May 1986, completed clutches of Tree Swallows disappeared, coinciding with excavations at both cavities by flickers. In one case, the disappearance of a swallow clutch and enlargement of the cavity by flickers occurred in only 48 hours. Flickers subsequently nested in the cavity. Flickers have been observed to remove and drop their own eggs from a disturbed nest (Baker 1975; Blomme 1983).

The incidents of nest usurpation reported here may result from similarities in the preferred nest site characteristics of Tree Swallows, Great Crested Flycatchers and Northern Flickers. Hole-nesting birds, especially secondary hole-nesting species, are assumed to face limited availability of cavities for breeding (von Haartman 1957; Nilsson 1984). The suitability of a nest site may be diminished if it is vulnerable to competitors (Snyder 1977). Ingold (1989) and Kerpez and Smith (1990) showed that similarities in the preferred nest site characteristics of starlings and native woodpeckers (e.g., Red-bellied Woodpecker, *Melanerpes carolinus*, Ingold 1989; Gila Woodpecker, *Melanerpes uropygialis*, Kerpez and Smith 1990) enable starlings to usurp nesting cavities, thus affecting cavity availability for these woodpeckers. In a study of the characteristics of cavities used by Tree Swallows, Rendell and Robertson (1989) found that unoccupied cavities were intermediate in several measures between those used by Tree Swallows and those used by larger species. They suggested that cavities with characteristics similar to those used by other species are avoided by Tree Swallows due to the greater threat of cavity usurpation.

Our observations, and other accounts of competition for nest-sites between hole-nesters (e.g., Erskine 1964; Ingold 1989; Kerpez and Smith 1990), provide direct evidence that competition for nesting cavities by interference and aggressive conflict is an important factor influencing cavity availability.

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Première mention d'une Avocette ruban (Pisces: *Nemichthys scolopaceus* Richardson, 1848) dans les eaux du Golfe du St-Laurent

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Seulement deux espèces de Nemichthyidae sont présentes dans les eaux canadiennes de l'Atlantique. L'une d'entre elle, *Nemichthys scolopaceus* Richardson, 1848, a été capturée jusqu'à maintenant au large des côtes sud de la Nouvelle-Ecosse et de Terre-Neuve. Pour la première fois, un spécimen de cette espèce a été pêché dans le Golfe du St-Laurent; c'est une femelle mesurant 1066 mm prise à environ 200 m (120 brasses) de profondeur à l'ouest de l'Ile Anticosti.

Only two species of the family Nemichthyidae are found in Canadian Atlantic waters. Until now all Canadian Atlantic specimens of *Nemichthys scolopaceus* Richardson 1848 were captured off the south coast of Nova Scotia and Newfoundland. A female of this mesopelagic fish was captured for the first time off the west coast of Anticosti Island in the Gulf of St. Lawrence.

Key Words: Avocette ruban, *Nemichthys scolopaceus*, Snipe eel, Golfe du St-Laurent, Gulf of St. Lawrence.

En mai 1988, un pêcheur capturait à l'ouest de l'Ile Anticosti dans la zone de pêche de l'OPANO 4Si (49°-51°N., 64°-66°O.), un spécimen de *Nemichthys scolopaceus* Richardson, 1848, en parfait état (Figure 1). Il a été capturé à une profondeur approximative de 200 m (120 brasses) avec un chalut à crevette d'un maillage de 4,4 cm (1,75 pouce). Il mesure 1066 mm LT. Le spécimen le plus long jamais rapporté mesurait 1445 mm et provenait de la Méditerranée (Roule et Bertin 1929). Aucune proie n'a été retouvée dans l'estomac de notre spécimen mais sa diète serait composée uniquement de crustacés, plus particulièrement de crevettes (Caridea, Penaeidea) et d'Euphausiacea (Nielsen et Smith 1978; Karmovskaya 1982) pouvant atteindre des tailles importantes par rapport au prédateur. En effet Roule et Bertin (1929) rapportent que l'on a retrouvé dans l'estomac d'un individu de 650 mm une crevette de 58 mm de longueur.

Notre spécimen est une femelle dont les ovocytes mesurent de 0,1 à 0,2 mm de diamètre. Il existe un dimorphisme sexuel important chez cette espèce. Le mâle mature ne possède plus le long bec caractéristique de la femelle et les mâchoires sont complètement dépourvues de dents. Les nageoires pectorales sont déplacées vers l'arrière et les narines s'allongent en un tube. Il semblerait que la femelle subisse également certaines légères transformations à la maturité sexuelle (Nielsen et Smith 1978). L'Avocette est ovipare (Nielsen 1986) et les larves leptocéphales sont bien connues et décrites par Roule et Bertin (1929) (leptocéphale "A") et par Smith (1979). Aucune larve n'aurait été trouvée dans les eaux canadiennes de l'Atlantique.

Une grande confusion taxonomique a longtemps existé chez les Nemichthyidae. A cause du dismorphisme sexuel accentué, on a souvent considéré les mâles comme des espèces ou des genres différents. Nielsen et Smith (1978) retracent bien les sentiers tortueux qu'a emprunté ce groupe de poissons depuis 1848. Selon les deux plus récentes révisions de cette famille, les Nemichthyidae comptent trois genres et de neuf (Karmovskaya 1982) à dix (Nielsen et Smith 1978) espèces. Deux de ces espèces se retrouveraient dans les eaux canadiennes de l'Atlantique: *Nemichthys scolopaceus* Richardson, 1848 et *Labichthys carinatus* Gill et Ryder 1882 (McAllister 1990).

N. scolopaceus est une espèce cosmopolite retrouvée dans les régions tropicales et tempérées des océans Indien, Pacifique et Atlantique entre les latitudes 43° sud et environ 55° nord (Masuda et al. 1984). On a capturé ce poisson pélagique depuis la surface jusqu'à des profondeurs de 2000 m, mais la profondeur optimale est mal connue. Cela explique que certains le considèrent soit comme un poisson mésopélagique (200 à 1000 m) et bathypélagique (1000 à 2000 m (Scott et Scott 1988) soit comme une espèce mésopélagique (Karmovskaya 1982; Nielsen et Smith 1978). Au Canada, l'Avocette ruban a été capturée au dessus du talus continental au sud des bancs de pêche de la côte sud de la Nouvelle-Ecosse: les bancs Le Have, Emerald, Ile de Sable et Banquereau, entre 0 et 2500 m (Jones 1882; Vladykov et McKenzie 1935; Scott et Scott 1988; Roule et Angel 1933; Nielsen et Smith 1978; Halliday et Scott 1969); trois spécimens ont été capturés à 457, 915 et 1132 m en 1981 dans le bassin de Terre-Neuve (environ 45° N et entre 45° à 48° O) (McKelvie 1984). Il n'y a

FIGURE 1. Spécimen de *Nemichthys scolopaceus* capturé dans les eaux du golfe du St-Laurent.

aucune mention dans la littérature de la présence de cette espèce dans le Golfe du St-Laurent.

L'identification de notre spécimen a été faite à l'aide de la monographie de Nielsen et Smith (1978). La présence d'un filament caudal et de trois lignes latérales indiquent qu'il s'agit du genre *Nemichthys*. Six (6) pores préoperculaires, dix (10) ou onze (11) pores postorbitales ont été dénombrés. Près de l'extrémité des nageoires pectorales, les pores en quinconce de la ligne latérale sont disposés de tel sorte qu'ils forment presqu'un carré dont la base est légèrement plus longue (1.9 mm) que la hauteur (1.8 mm) (voir Figure 21B de la monographie précitée). Le dos est brun pâle tandis que le ventre est brun foncé, aucune tâche ou barre ne sont présentes sur le spécimen.

Ce spécimen est conservé dans les collections de référence du ministère des Pêches et des Océans à l'Institut Maurice-Lamontagne à Mont-Joli sous le numéro de catalogue 98-067-01, 1918.

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Mixed-species Mating Chases of Fox Squirrels, *Sciurus niger*, and Eastern Gray Squirrels, *S. carolinensis*

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Koprowski, John L. 1991. Mixed-species mating chases of Fox Squirrels, *Sciurus niger*, and Eastern Gray Squirrels, *S. carolinensis*. Canadian Field-Naturalist 105(1): 117–118.

Observation of individually marked Fox Squirrels and Eastern Gray Squirrels during 27 mating chases yielded information on the frequency of male participation in mating bouts of congeneric females. Males rarely participated in the mating bouts of females of the other sympatric squirrel species (1.9% of participating males) and copulation was not attempted. All instances of mixed-species chases involved Fox Squirrel males participating in Eastern Gray Squirrel female mating bouts.

Key Words: Fox Squirrel, *Sciurus niger,* Eastern Gray Squirrel, *Sciurus carolinensis*, reproduction, Kansas.

Fox Squirrels (*Sciurus niger*) and Eastern Gray Squirrels (*S. carolinensis*) are closely related species (Moore 1960) that are sympatric throughout much of their ranges. The breeding seasons of both species overlap, with most mating during late December-January and late May-June; Fox Squirrel matings peak slightly earlier in the breeding season than Eastern Gray Squirrel matings (Brown and Yeager 1945). Females are in estrus for less than 1 day; however, males may be attracted to females beginning about 5 days pre-estrus (Thompson 1977). As many as 34 males congregate in a female's home range (Goodrum 1961). Males pursue and compete for access to the female as she moves throughout her home range (Benson 1980; Thompson 1977). Hybridization between the two species is not known (Gurnell 1987: 159) and only Moore (1968) has reported a Fox Squirrel involved in a Eastern Gray squirrel mating chase, ending without a copulation attempt. This note reports on my observations on the frequency of males of different species mixing in mating chases.

Squirrels were trapped as part of a study on the social and mating system of tree squirrels from May 1986 to January 1989 on a 4.2-ha, Black Walnut (*Juglans nigra*)-dominated parkland on the University of Kansas campus, Lawrence, Douglas County, Kansas. Eastern Gray Squirrels and Fox Squirrels were found on the study area in an approximate ratio of 3:1, respectively (Koprowski, *in press*). Squirrels were ear-tagged (Monel no. 1, National Band and Tag Co., Newport, Kentucky) and uniquely marked for visual identification by freeze marking (Rood and Nellis 1980) or attaching a symbol-coded, vinyl ear tag (Koprowski et al. 1988). Squirrels were observed with binoculars during the breeding season and the activities of the mating-chase participants were recorded. The absence of a shrub stratum and the habituation of the squirrels to human presence facilitated observation.

I observed 14 Eastern Gray Squirrel and 13 Fox Squirrel mating chases from December 1986 to June 1989. On 3 occasions I observed adult male Fox Squirrels (2 individuals) involved in a Eastern Gray Squirrel mating chase (5 and 6 January 1988); I never observed a Eastern Gray Squirrel male participating in a Fox Squirrel mating chase. Eastern Gray Squirrel chases averaged 11.2 ± 4.9 S.D. males per female, while Fox Squirrel chases averaged 5.8 ± 0.8 S.D. males per female. Male involvement in chases of females of the sympatric squirrel species was rare with Fox Squirrels composing only 1.9% of the 157 participants in estrous female Eastern Gray Squirrel chases. The male Fox Squirrels followed the aggregation of adult male Eastern Gray Squirrels around the female and engaged in the extensive agonistic encounters that occur among males. Although a female ran within 1 m of an adult male Fox Squirrel, there was no copulation attempt. Male participation in the chases was less than 1 h. Mixed-species mating chases did not result from confusion of individuals involved in simultaneous intraspecific chases because no Fox Squirrel females were in estrus within at least 500 m of the study area when mixed-species chases occurred.

Male rodents discern reproductive condition of females through olfaction (Brown 1979; Harris and Murie 1984), and chemical cues likely attract male tree squirrels from as far as 600 m to the home range of an estrous female (Thompson 1977). Males frequently approach and smell the genitalia of females, especially during the breeding season (Thompson 1977). Although chemical cues appear useful in locating the home range of a female, males that lose visual contact of the female during mating chases appear confused and have difficulty relocating the female. After males have lost sight of the female, I have observed males following conspecific males and juveniles, or other species such as Eastern Cottontails (*Sylvilagus floridanus*)

and numerous species of foraging birds. These observations suggest that olfactory cues do not indicate a female's immediate location, probably due to the dispersion of scent as she traverses her home range during the mating chase. Visual cues are likely necessary for the immediate location of the female.

Unfortunately, chemical communication in tree squirrels has received little study and isolation of stimulatory chemicals has not been attempted. Perhaps male squirrels are occasionally attracted to estrous females of other species of the same genus by similar female pheromones and/or limitations of male olfactory capabilities. Male Old Field Mice (*Peromyscus polionotus*) are attracted to the scent of estrous female Deer Mice (*P. maniculatus*) in addition to conspecific females (Moore 1965). Another possible explanation for mixed-species mating chases is that males of other squirrel species are only attracted by the movement, calling, and general commotion characteristic of tree squirrel mating chases. Future research on chemical communication and olfactory capabilities of tree squirrels should prove useful in elucidating the potential role of olfactory cues in maintaining reproductive isolation of Fox Squirrels and Eastern Gray Squirrels in areas of sympatry.

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A Communal Overwintering Site for the Canadian Toad, *Bufo americanus hemiophrys*, in the Northwest Territories

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A communal overwintering site used by several hundred Canadian Toads was discovered in northern Wood Buffalo National Park, Northwest Territories near the species' northern limit of distribution. Toads emerged from the hibernation site during the first week in May and returned about 1 September so that these amphibians likely have an 8.5-month hibernation period.

Key Words: Canadian Toad, *Bufo americanus hemiophrys*, hibernation, Northwest Territories.

Amphibians and reptiles are represented by only five species in the Northwest Territories (NWT) and these occur almost entirely in the forested portions. Short, cool and sometimes dry summers, long cold winters, and a scarcity of suitable hibernating sites are all factors which make it difficult for these ectothermic animals to survive in the north.

All five species of amphibians and reptiles in the NWT occur in the Fort Smith, NWT, area where the Northern Leopard Frog (*Rana pipiens*), is rare and the Red-sided Garter Snake (*Thamnophis sirtalis parietalis*) is probably restricted to the vicinity of suitable hibernacula in collapsed limestone sinkholes in Karst topography (Brophy 1988; Larsen and Gregory 1988). Two species, the Wood Frog (*Rana sylvatica*) and Boreal Chorus Frog (*Pseudacris triseriata maculata*) are freeze tolerant and the latter occurs as far north as the Mackenzie River valley west of Great Bear Lake while the Wood Frog reaches the Mackenzie River delta near the Arctic coast (Hodge 1976; Cook 1984).

Toads require wetlands for breeding, and feed in both wetlands and drier uplands. For overwintering they burrow individually in loose soil (Tester and Breckenridge 1964b). Suitable feeding and breeding habitat is widespread in the NWT but a scarcity of suitable hibernacula within range of wetlands and foraging areas may prevent toads from spreading more widely. This paper provides information on a hibernating site of the Canadian Toad near its present northern distribution limit.

Observations

In Fort Smith cool weather prevailed in early May 1989. Daytime high temperatures and overnight lows on 3, 4 and 5 May respectively were 12.0°C and 0.2°C; 4.5°C and -6.0°C; 23.5°C and -1.2°C. There was 0.8 mm of precipitation on 3 May (rain and snow), and a trace of rain on 4 and 7 May (all weather data from Flight Service Station, Transport Canada, Fort Smith). On 7 May 1989, Wood Frogs and Boreal Chorus Frogs were in full chorus in wetlands along Highway 5 leading into Fort Smith. On the road just west of Little Buffalo River and 61 km west of Fort Smith (60°02′N, 112°53′W) I found six road-killed toads. Two of these retained sufficient details to allow the identification of the prominent cranial crests between the eyes diagnostic of the Canadian Toad (Cook 1984). These were later confirmed by F. R. Cook (personal communication) to be *Bufo americanus hemiophrys* (Canadian Museum of Nature, NMC, Catalogue number 32420). On 14 May I searched the same area for additional toads in better condition, and I noticed a large number of small oval holes in a low sandy hillside on the north side of the road. I hypothesized that the hill could have been an overwintering site for toads, some of which had been killed by vehicles as the toads, upon emerging from hibernation, had travelled on the road to reach spawning or feeding areas in nearby wetlands.

I returned on 16 May for a more detailed examination of the area. The exposed hillside was most likely created when the present all-weather highway was constructed in the middle 1960s. The road cut is about 120 m long and the 8-10 m wide slope is at an estimated 40° angle. The hillside has a generally southern exposure. A convenient reference mark is metal hydro pole No. 371 directly across the road from the hillside.

The hill is on the edge of a mixed-wood forest containing Trembling Aspen (*Populus tremuloides*), White Spruce (*Picea glauca*), Black Spruce (*Picea mariana*), and Jack Pine (*Pinus banksiana*). Across the road and west of the hill, the upland forest gives way to an area of increasing wetness with larch (*Larix laricina*), willows (*Salix* spp.), Swamp Birch (*Betula pumila*), and sedges (*Carex* spp.). Permanent waterbodies (standing water, except during spring run-off or when water floods over beaver dams after periods of heavy rain) are found along the highway several hundred metres west of the toad wintering site.

The exposed hillside contains loose sand and is only lightly vegetated with isolated small aspen and

Prickly Rose (*Rosa acicularis*). The hillside will be revegetated slowly, if at all, as Bison (*Bison bison*) and other mammals, mostly carnivores, track through the area, continuously disturbing the soil. Higher up on the slope of the hill, particularly near the western edge where most holes were found, vegetation is more luxurious with scattered plants of Sage (*Artemisia canadensis*) and Common Horsetail (*Equisetum arvense*) having gained a foothold.

On 16 May 1989, I estimated there were about 500 holes in the hillside, but on 5 May 1990, when I made a more accurate count, I tallied at least 600 holes. About 500 of these were in the westernmost 50 m of the hillside (closest to standing water in the area) and four different 1 m^2 plots sampled in this area contained 19, 27, 22 and 41 holes respectively. In the eastern part of the hill only a few holes occurred, most of them on the middle or upper part of the slope.

The holes measured on 16 May 1989 were slightly wider than their height and somewhat oval in cross-section. Two holes measured 41×31 mm and 44×18 mm, and were about 80 mm deep. The holes angled slightly downward from the horizontal. Most of the holes were in the upper, vegetated part of the hillside and not in the exposed lower part where soil disturbance was more likely to occur. A close scrutiny of undisturbed sandy areas around the holes, particularly near the top of the hillside, revealed innumerable scratch markings. Although the ground was completely covered by these tracks in many places, individual tracks clearly showed the plume-like pattern of the hind feet of toads. As I worked near the toad hibernaculum I heard frequent and long drawn-out musical trills, almost wavering in quality, coming from the nearby wetlands. They were quite different from the calls of the Wood Frog or Chorus Frog, agreed with descriptions in Cook (1984), and I took these calls to be the spring song of toads.

On 29 April 1990, the hibernation site was clear of snow and there was no evidence of activity by toads. Early May was as cool in Fort Smith as in the previous year. Daytime high temperatures and overnight lows on 3, 4 and 5 May respectively were 13.3°C and -5.5°C; 20.2°C and 0.2°C; 11.4°C and 2.0°C. I made note of a light rain at 1530 hrs on 4 May, recorded by Flight Services, Fort Smith, as a trace.

On 26 April 1990, no activity was noted on the hillside but on 5 May I found five fresh road-killed toads within 20 m of the western part of the hillside (snout-vent lengths 60, 60, 64, 65, 65 mm). Again the hillside was covered with toad tracks and a close scrutiny showed that tracks were more recent than the impressions left by the light rainfall of 4 May. On the edge of a nearby pond I saw three large sand-covered toads and in the pond about eight toads were seen swimming. I did not hear any toad calls.

On 19 May I found several other small toad hibernacula, all on the north side of the road as far as 3.3 km west of the major hibernaculum.

In 1989, brief visits to the area on 4 and 21 June showed that many of the exit holes on the hillside had been filled in as a result of mammal disturbance, rain and wind. Toad tracks, so conspicuous on 16 May, had been obliterated by rainfall. From the highway there was little to indicate that the hillside had been a major toad hibernaculum.

In the afternoon of 30 August I saw that practically none of the exit holes made by toads in May remained. However, about 10 small piles of loose wet sand, resembling those of earthworm castings were noted in the west part of the hillside. By carefully digging below five of the fresh castings I succeeded in finding three toads, positioned vertically, head uppermost, about 10 cm vertically below the surface. They measured 31, 32 and 62 mm snout-vent length. Toads burrow backwards and their position in the burrow tended to confirm this.

An examination in the morning of 2 September, my last visit of the 1989 season, showed well over 200 fresh castings of loose sand, and the entire hillside was covered with the recent scratchy tracks of toads. Clearly, a mass movement of toads had taken place during the previous two days or three nights.

Discussion

Studies by Storey and Storey (1986) involving supercooling and formation of freeze protecting chemicals (cryoprotectants) in terrestrially-hibernating amphibians including Wood Frog, Chorus Frog, and American Toad, *Bufo a. americanus*, indicated that while the two species of frogs were freeze-tolerant to -8°C and produced glucose as a cryoprotectant, the toad was neither tolerant of supercooling nor showed any accumulation of cryoprotectants. These studies, in part, may explain why the ranges of the Wood Frog and Boreal Chorus Frog extend far into northwestern NWT and why these species can overwinter at or near the surface, while the Canadian Toad burrows into the ground below the freezing level to survive the winter.

The hibernaculum described is used by 500 or more toads. Individual burrows reached only 10 cm when measured on 30 August but undoubtedly the toads burrow deeper when the frostline lowered. Vertical movements of radio-active tantalum-marked toads of the same taxa in Minnesota during winter indicated that some toads appeared to avoid freezing soil by burrowing deeper even in midwinter whereas other toads burrowed as deep as 132 cm by early November

and remained in this position (Tester and Breckenridge 1964a).

In the Little Buffalo River hibernaculum, entrance burrows were nearly vertical. Exit burrows in spring angled nearly horizontally and the short smooth empty exit burrows and relative lack of castings near the opening would suggest that toads had remained in the burrow close to the surface for some time, and perhaps had moved back and forth in that portion of the burrow.

Toads at the Little Buffalo site emerged in 1989 and 1990 from the overwintering site during the first week in May and in 1989 they returned to the hibernaculum about 1 September. It is probable, therefore, that at this northern location these toads would be in hibernation for as long as 8.5 months of the year. It is perhaps remarkable that toads can store sufficient body resources by early fall after a short summer (which also includes the energy draining breeding season) so that they can successfully survive underground. Some toads, perhaps, even have to expend energy in fall to burrow deeper in the soil as temperatures and insulation of snow cover dictate. Studies by Dimmitt and Ruibal (1980) have demonstrated the prodigious feeding ability of some anurans with restricted activity periods in the arid southwest. They found that spadefoot toads (*Scaphiopus couchi*) consumed up to 55% of their body weight in a single feeding, while true toads (*Bufo cognatus*) required a longer period, from 11 to 22 feedings, to obtain a year's fat reserve. The latter are well within the similarly short activity period of the northern cold environment.

The hillside now used by hibernating toads may well have been manmade during road construction. There are a number of similar hillsides along Highway 5 in northern WBNP and most of them have wetlands nearby. Roberts and Lewin (1979) found that Canadian Toads in northeastern Alberta gradually decreased in abundance at distances < 40 m from water and that these and other amphibians did not occur in dry sandy Jack Pine forest habitat. Perhaps this habitat, so common in WBNP, acts as a barrier to toad dispersal.

The toad hibernaculum near the Little Buffalo River lies within a national park and therefore receives protection. Toads emerge from the overwintering site before tourists visit the north and as tourists usually leave before toads return to the hibernaculum, summer visitations for interpretive purposes should not be disruptive if conducted with care. If traffic patterns on the highway and toad movements change resulting in increasing mortality, thought should be given to construction of fences or culverts (such as now in use in Europe) to allow toads safe passage to spawning areas.

Further studies may well indicate that additional overwintering sites occur along the highway in similar situations.

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A Coyote, *Canis latrans*, and Badger, *Taxidea taxus*, Interaction Near Cypress Hills Provincial Park, Alberta

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A sighting was made of a Coyote (*Canis latrans*) and Badger (*Taxidea taxus*) hunting together 22 September 1988, in southeastern Alberta. Possible benefits for the Coyote were obtaining ground squirrels escaping the Badger. The latter may have been provided with a warning of impending danger. A review of published observations of Coyote-Badger interactions shows they vary from mutually affectionate and cooperative to harassment and predation by Coyotes of Badgers.

Key Words: Coyote, *Canis latrans*, Badger, *Taxidea taxus*, hunting, relationship, symbiosis, phoretic, North America.

Knowledge of interspecific association between Coyotes (*Canis latrans*) and Badgers (*Taxidea taxus*) dates back into history. Dobie (1949) owns a clay jar from Casas Grandes, Chihuahua, believed to be a thousand years old. It has the head of a Coyote modeled in bas-relief on one side, and the head of a Badger on the other. Dobie also writes "In the tales of the Navajo, coyote and badger go around with each other hunting together and calling each other cousin".

In the scientific literature there have been periodic reports of such associations. In some cases play and affection have been exhibited. Aughey (1884) made an observation of which he wrote "the coyote would go in front of the badger, lay its head on the latter's neck, lick it, jump into the air, and give other expressions of unmistakable joy", and later goes on "this playing and fondling of each other was kept up for over half an hour". Dobie (1949) quotes Royal Warren quoting a report, in Yellowstone Nature Notes, of a Badger and a Coyote playing together with the intimacy and freedom of two bear cubs. However, most interactions between the two species appear neutral or mutually beneficial, referring to observations of Badgers and Coyotes travelling or hunting together (Anonymous 1947; Aughey 1884; Cahalane 1950; Dobie 1949; Lehner 1981; Robinson et al. 1947; Seton 1909; Young et al. 1951). Cahalane (1950) reports an observation from North Dakota where a Coyote and a Badger ran simultaneously through a prairie dog colony, each catching a frightened prairie dog as it ran for shelter. However, antagonistic behaviour between Coyotes and Badgers does also occur. Rathburn et al. (1980) described two instances of Coyote predation on Badgers. Conversely, den site depredation of nine Coyote pups by a Badger was reported by Young et al. (1951). Dobie (1949) cites an instance of a Coyote harassing a Badger that was digging for a prairie dog and another where a Coyote grabbed a ground squirrel from a Badger the moment he brought it out of the hole. In the same book he states "Coyote remains have been found in Badger stomachs also. Out of 14829 Coyote stomachs examined by Sperry, 47 contained Badger remains; 12 of the 47 occurrences were identified as carrion".

Additional accounts of Coyote-Badger interactions are useful in the continuing analysis of the relationship that exists between these two carnivores. Here, we report our observations of a Coyote and Badger together on 22 September 1988 approximately 5 km north of Cypress Hills Provincial Park in southeastern Alberta.

The terrain was rolling mixed prairie, and had been used recently as cattle pasture. Both predators appeared to be healthy adults with no indication of physical abnormalities. When first observed, the Badger was digging vigorously, occasionally stopping to look around. The Coyote was alert although relaxed enough to sit or lie down periodically. Neither animal displayed any antagonistic behaviour, although the two were only 1 m apart.

After twenty minutes of observation, H.P.L.K. attempted to move closer. The Coyote tolerated the approach to within 10 m before moving about 15 m to the west, where it sat down. Soon the Badger became restless, perhaps due to the close proximity of the observer or to the sudden departure of the Coyote. The Badger stopped digging, looked around and ran towards the Coyote. Both then ran off in a north westerly direction. Initially the Badger was left far behind, but after about 700 m, the Coyote slowed down, and the Badger caught up.

Examination of the site revealed several fresh excavations but no prey remains. Evidence of Richardson's Ground Squirrel (*Spermophilus richardsonii*) activity in the area was abundant and we believe the Badger was excavating burrows to prey on the rodents. We suspect the Coyote was

prepared to kill ground squirrels attempting to escape the digging Badger. The benefit to the Badger is not clear, although a Badger digging with its head underground would benefit if a nearby Coyote communicated alarm at the approach of a potential enemy. Hibbard (1963) reported a Badger feeding on a sheep carcass, and therefore, a Badger in a different situation might profit if the Coyote killed a large prey species such as a deer (*Odocoileus* sp.) or Pronghorn Antelope (*Antilocapra americana*).

Aughey (1884) concluded that Coyotes and Badgers do not associate by accident but must have an affinity for each other. He also stated "It is not at all improbable that future investigation may show this fellowship to be a case of symbiosis". Dobie (1949) took this view even further: "There is, I am positive, a relationship between the coyote and the badger not sensible to civilized man". Later on he also speaks of a kind of mutual attraction, an obscure rapport.

Seton (1909), however, after hearing some reported cases of Badger-Coyote associations, concluded simply that they likely were involuntary on the part of the Badger, since the Coyote knows very well that the Badger would dig out ground squirrels, flushing some, thus giving the Coyote a chance to share in the spoils. Young et al. (1951) agreed, pointing out that "Since the two animals are noted as rodent depredators may account for the apparent friendship that sometimes develops between them, and probably results in close cooperation in digging out burrowing rodents for food".

Finally, Lehner (1981) postulated that there is a mutual attraction between the two species but "Whether one or both species seeks out the other is not known". Meeting may be somewhat accidental or promoted by their aggregation at a common prey resource". He went on to speculate that "Continued associations are probably prompted by both individuals learning that food may be obtained (perhaps more efficiently) by the association and enhanced by the coyotes' own social tendencies". He concluded that Coyote-Badger associations are best considered as phoretic (accidental and non-obligatory) rather than a form of social symbiosis.

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Range Extensions and Records of Rare Fishes From the Coastal Waters of British Columbia

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Gillespie, Graham E. 1991. Range extensions and records of rare fishes from the coastal waters of British Columbia. Canadian Field-Naturalist 105(1): 124-126.

Records of four rare species: the Aurora Rockfish, *Sebastes aurora*, and Shortbelly Rockfish, *S. jordani*, Roughscale Sole, *Clidoderma asperrimum*, and Pearly Prickleback, *Bryozoichthys marjorius*, are presented. Northward extensions of known range are described for *Sebastes aurora, S. jordani. Clidoderma asperrimum* is primarily an Asiatic species known also from the Aleutian Islands to northern California, though it is rarely reported. *B. marjorius* ranges from the Aleutian Islands to southern British Columbia. Both of the rockfishes are found between Baja California and British Columbia, with centres of abundance off California.

Key Words: Distribution, Roughscale Sole, *Clidoderma asperrimum,* Prickly Prickleback, *Bryozoichthys marjorius,* Aurora Rockfish, *Sebastes aurora,* Shortbelly Rockfish, *Sebastes jordani.*

Several fish species recently captured off the coast of British Columbia by the staff of the Pacific Biological Station or commercial fishermen represent rare occurrences or extensions to known ranges.

Clidoderma asperrimum (Pleuronectidae)

The Roughscale Sole was recorded from British Columbia by Welander et al. (1957), on the basis of a specimen captured in 1955 in Estevan Deep (approximately 49°04′N, 127°57′W, University of Washington, catalogue number UW 10739). A second specimen from the same location was also reported as a footnote. The species' known range is from the Kurile Islands to Korea (Grinols 1965), and from the Aleutian Islands to Punta Gorda (Lea et al. 1989), but it is rarely reported in the northeastern Pacific.

The Roughscale Sole is a right-eyed flatfish characterized by a lack of normal scales, and the presence of bony tubercles on the eyed side, the larger tubercles arranged in six longitudinal rows. The blind side of the fish lacks scales and is a uniform grey-brown colour; not creamy white as in most other northeast Pacific flatfish.

A female Roughscale Sole, 524 mm total length (TL), was trawled from 439-549 m of water west of Langara Island, British Columbia (approximately 54°15′N, 133°10′W), in March 1988. It was deposited in the Royal British Columbia Museum (formerly British Columbia Provincial Museum; catalogue number BCPM 990-104).

A second female Roughscale Sole, 486 mm TL, was trawled off the west coast of Vancouver Island (catalogue number BCPM 990-105). Exact date and locality of capture are not available. These specimens represent the third and fourth verifiable records from Canadian waters.

Dorsal and anal fin counts from the Langara specimen (89 and 72 rays, respectively) were at the upper extreme of the published ranges (Welander et al. 1957; Lea et al. 1989). All other morphometrics and meristics were within published ranges.

Bryozoichthys marjorius (Stichaeidae)

The holotype of the Pearly Prickleback was captured by trawl from 220 m near Forrester Island, southeast Alaska (54°42′N, 134°05′W) and deposited in the Canadian Museum of Nature (formerly National Museum of Canada; catalogue number NMC 66-268). The species description included a specimen from Unalaska Island, originally a paratype of the Nutcracker Prickleback, *Bryozoichthys lysimus* (McPhail 1970). No specimens were known from areas between these two localities. One paratype (University of British Columbia, catalogue number UBC 69-1) lacked collection locality data. The geographic range has since been expanded to include Adak Island and Petrel Bank in the Aleutian Islands and Gulf of Alaska (Amaoka et al. 1977).

Peden and Wilson (1976) documented the first Canadian occurrence and southernmost record of the species, at La Perouse Bank (48°24.4′N, 126°03.9′W, California Academy of Sciences, catalogue number CAS 15362). A second Canadian specimen was collected 18 August 1982, in Alice Arm, Observatory Inlet, Portland Channel (55°22.0′N, 129°37.0′W, Royal British Columbia Museum, catalogue number BCPM 982-328) (Alex E. Peden, personal communication).

A 262 mm TL Pearly Prickleback has since been captured by bottom trawl 26 July 1989, in 300-330 m of water northwest of Langara Island (54°13.9′N, 133°50.2′W). It was deposited in the Royal British Columbia Museum (catalogue number BCPM 990-

116). This represents the third record of the species in Canadian waters.

The specimen was distinguished from *Bryozoichthys lysimus* by its long nasal tube, approximately one half of the eye diameter, and its pelvic fins being longer than the eye diameter (Amaoka et al. 1977). The fin counts were: dorsal LXVII; anal I,52; and pectoral 15.

Sebastes aurora (Scorpaenidae)

The Aurora Rockfish was first recorded in Canadian waters 19 March 1967, southwest of Amphitrite Point, Vancouver Island (49°46.8′N, 126°35′W), in 421 m (Westrheim 1968). Four specimens were deposited at the University of British Columbia as UBC 67-12 and 13. Four additional specimens were collected from the same area on 13 April 1967 (Canadian Museum of Nature, catalogue numbers NMC 67-728 and 729). Snytko (1986) extended the range northward to Queen Charlotte Sound (51°12′N, 129°22′W). The southern record for the species is Cedros Island, Baja California (Allen and Smith 1988)

A female Aurora Rockfish, 370 mm fork length (FL), was taken in March, 1988, west of Langara Island (approximately 54°15′N, 133°10′W), in 439-549 m. It was placed in the Royal British Columbia Museum (catalogue number BCPM 990-103), and represents a northward range extension of approximately 180 nautical miles.

The nasal, preocular, supraocular, postocular, tympanic, parietal and nuchal spines were all present, strong and sharp. There were 24 gill rakers on the first arch of the left side. The symphyseal knob was weakly developed, and the premaxillaries each possessed a moderate dentigerous knob, similar to but smaller than those characteristic of the Splitnose Rockfish, *Sebastes diploproa*. The second anal spine was equal in length to the third, but was twice as thick, and broadly curved posteriorly.

Sebastes jordani (Scorpaenidae)

The Shortbelly Rockfish was first recorded in Canadian waters 14 March 1965, from La Perouse Bank, off southwest Vancouver Island (48°22.7′N, 126°02′W), in 183-210 m, totalling 32 specimens (University of British Columbia catalogue number UBC 65-255, 16 specimens; Canadian Museum of Nature catalogue number NMC 65-131, 16 specimens) (Westrheim and Pletcher 1966). Snytko (1986) extended the range northward to Kyuquot Sound (48°58′N, 126°43′W). Allen and Smith (1988) reported the species from Granite Island, Kenai Peninsula, Alaska (approximately 59°30′N, 149°30′W), however, this was regarded as a questionable record, with no verification of identification and no specimens saved. The southern record for the species is San Benito Island, Baja California (Moser et al. 1977).

The species is uniquely distinguished from its congeners by its anus being positioned midway between the pelvic and anal fins, at least one eye diameter anterior to the origin of the anal fin, its weak head spines and convex to flat interorbital space (Phillips 1957).

Several Shortbelly Rockfish were collected by midwater trawl 11 May 1989, in Queen Charlotte Sound (51°15′N, between 128°50′W and 129°05′W), in 187-192 m. One specimen, a 189 mm FL female, was deposited in the Royal British Columbia Museum (catalogue number BCPM 990-107), and represents a verifiable northward range extension of approximately 120 nautical miles, into Queen Charlotte Sound.

The nasal, preocular, tympanic and parietal spines were weakly present, as were a pair of weak parietal ridges. The second anal spine was equal in strength to the third, and slightly shorter. The distance from the anal opening to the origin of the anal fin was 1.1 times the eye diameter.

Acknowledgments

I would like to thank Captain Bob Ingram of the F/V ARCTIC HARVESTER for supplying the Langara specimens of *C. asperrimum* and *S. aurora,* Captain Bruce Ritchie of the F/V SENA II for the Vancouver Island specimen of *C. asperrimum*, and Beth Scott of the University of British Columbia for providing the specimen of *S. jordani.* Alex E. Peden of the Royal British Columbia Museum provided specimens and information on both *Clidoderma* and *Bryozoichthys.* Alex E. Peden, Bruce M. Leaman and three anonymous referees kindly offered suggestions on a draft of the manuscript.

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Newsletter/Bulletin: Canadian Association of Ichthyologists

The fourth newsletter/bulletin of the Canadian Association of Ichthyologists appeared 1 January 1991. Its 28 pages contain a feature on the Institute of Ichthyology, University of Guelph; News items on the Biodiversity Newsletter, Honourary Foreign Member (Dr. Bror Jonsson), the Southern Ontario Chapter of the American Fisheries Society, and the Sustainable Fisheries Network; a "new book" section listing five items; a meetings section listing 15 upcoming society or symposium gatherings; and a current research and publications section with contributions from 43 active ichthyologists in Canada. It now has a circulation of approximately 200 copies and can be obtained from Brian W. Coad, Editor, Ichthyology Section, Canadian Museum of Nature, P. O. Box 3443, Station D, Ottawa, Ontario K1P 6P4.

Herpetological Surveys in Central Canada

Two major distribution surveys for amphibians and reptiles in central Canada are continuing in 1991. Both distribute observation cards and instructions to interested potential participants. Both have published distribution summaries for information received in previous years and both will be publishing up-to-date revised atlases of distribution of their provincial herpetofaunas in the future.

In Ontario write: Ontario Herpetofaunal Summary, Ontario Field Herpetologists Business Office, R.R. #22, Cambridge, Ontario N3C 2V4.

In Quebec write: Atlas des amphibiens et des reptiles du Quebec, c/o Dr. J. R. Bider, St. Lawrence Valley Natural History Society, Ste-Anne-de-Bellevue, Quebec H9X 1C0.

Publication of *The Canadian Field-Naturalist*

With the publication of this number of *The Canadian Field-Naturalist* we will have mailed eight issues since July 1990. My thanks to all those who have made this possible, and particularly to M.O.M. Printing, Ottawa.

FRANCIS R. COOK

News and Comment

1990 John Stoneman Award to Donald E. McAllister

On 9 November 1990, at the opening of an exhibit on coral reefs in the Victoria Memorial Museum building, Ottawa, the 1990 John Stoneman Award recognized Dr. Donald E. McAllister for his contribution to saving tropical coral reefs and Canadian endangered fish species. John Stoneman, Director of the Foundation for Ocean Research and President and Executive Producer of Mako Films, together with Dr. Alan R. Emery, Director of the Canadian Museum of Nature (formerly National Museum of Natural Sciences), made the presentation. Dr. McAllister has been an honorary member of the Ottawa Field-Naturalists Club since 1987.

New Journal: *Canadian Biodiversity*

The Canadian Museum of Nature (formerly the National Museum of Natural Sciences, National Museums of Canada) has launched a new publication, *Canadian Biodiversity*, with the issuing on 26 March 1991 of volume 1, number 1. *Canadian Biodiversity* has widesweeping and overlapping goals for its envisioned niche: to publish articles on biodiversity, to bridge the gaps between professional disciplines and the public, to communicate information on Canadian and world biodiversity to Canadians, to circulate news on Canadian biodiversity to other countries, to express views on the needs and value of biodiversity research, to discuss methods, principles, ethics of biodiversity conservation, and to review books and major articles on biodiversity. The 48 pages of its inaugural issue feature philosophical articles on "What is biodiversity ?", "Biodiversity conservation: a moral as well as practical imperative", "Why save biodiversity?" and analysis articles on avian biodiversity in Guyane francaise, maps of numbers of tree species in Canada, and a discussion of an equal-area grid map. There is also coverage of several global conventions, strategies, and meetings involving the UNEP, the CCIUCN, and the IUCN, as well as biodiversity news notes and a niche for book and periodical reviews. *Canadian Biodiversity* will be published at least twice a year and is available in both English and French editions to individuals at $10.00 Canadian per year in Canada and $10.00 U.S. in developed countries elsewhere. Subscriptions for less developed countries are $5.00 Canadian. Library subscriptions are $20.00 Canadian in Canada, $20.00 U.S. in developed countries, and $10.00 Canadian in less developed countries. For subscriptions, or to submit manuscripts or news, write: Dr Don E. McAllister, Scientific Editor, Canadian Centre of Biodiversity, Canadian Museum of Nature, P. O. Box 3443, Station D, Ottawa, Ontario, Canada K1P 6P4.

International Marinelife Alliance Canada becomes Ocean Voice

Sea Wind volume 5, number 1, January-March 1991, has announced that The International Marinelife Alliance Canada, in a move to reduce the characters in its name and clearly assert its own distinct individuality, has rechristened itself **Ocean Voice**. Ocean Voice will continue quarterly publication of the proactive marine conservation journal *Sea Wind*, and provide it to the International Marine Alliance U.S.A. *Sea Wind* currently has a circulation through Ocean Voice alone to over 500 individuals and institutions. Regular membership in Ocean Voice is $20.00, student membership $10.00 and institutional subscription $50.00.

Ocean Voice has also published a 16-page pamphlet *The Green School Checklist* with illustrations of major ecosystems rich in biodiversity and containing 100 questions aimed at junior to senior high school students. "No" responses lead to a list of actions that would lead to score improvement. Copies of *The Green School Checklist* are $2.50 each plus $1.00 for postage and handling. Quotes on bulk orders are available.

Both publications are available from Ocean Voice, 2883 Otterson Drive, Head Office, Ottawa, Ontario K1V 7B2, Canada; Attention: Dr. D. E. McAllister, President & Editor.

Newsletter/Bulletin: Canadian Association of Ichthyologists

The fourth newsletter/bulletin of the Canadian Association of Ichthyologists appeared 1 January 1991. Its 28 pages contain a feature on the Institute of Ichthyology, University of Guelph; News items on the Biodiversity Newsletter, Honourary Foreign Member (Dr. Bror Jonsson), the Southern Ontario Chapter of the American Fisheries Society, and the Sustainable Fisheries Network; a "new book" section listing five items; a meetings section listing 15 upcoming society or symposium gatherings; and a current research and publications section with contributions from 43 active ichthyologists in Canada. It now has a circulation of approximately 200 copies and can be obtained from Brian W. Coad, Editor, Ichthyology Section, Canadian Museum of Nature, P. O. Box 3443, Station D, Ottawa, Ontario K1P 6P4.

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FRANCIS R. COOK

Book Reviews

Zoology

Snakes of Eastern North America

By Carl H. Ernst and Roger W. Barbour. 1989. George Mason University Press, Fairfax, Virginia. 282 pp., illus. + plates. U.S. $62.50.

In the preface to this book the authors state that their aim in producing the book was to assemble all the information on identification and life histories of eastern North American snakes that has accumulated since the publication of Wright and Wright's *Handbook of Snakes* (1957). Collecting and summarizing thirty-some years of literature is a daunting task, and the authors are to be commended for their effort. The production of such a book is timely, and demonstrates that the work required can be done. Perhaps a companion volume on western species is in the offing?

The book appears to be aimed at a broad, rather than restricted to an academic, readership. Certainly all readers can get some valuable information from the book, be it merely to identify the snakes encountered by school children. Professional herpetologists will find it both a useful summary of information and a source of hundreds of citations.

As the authors state in the preface, emphasis is placed on ecology, behaviour, and taxonomy rather than on physiology and morphology. The format of the book is similar to that of Wright and Wright, with each species account containing headings of identification, distribution, habitat, behaviour, reproduction, and food. Generally it is an improvement over Wright and Wright, being less anecdotal, containing more information and having a single-volume format. I found the keys easy to use and appreciated the range maps' covering the entire range of the species, even into South America.

Most species accounts contain at least one black-and-white photograph. Those that do not, require turning to the colour photos which are grouped together in the centre of the book. Each species is represented by at least one colour photo.

The families of snakes (subfamilies for the Colubridae) are arranged phylogenetically. Genera are arranged alphabetically within families or subfamilies. I would have preferred the entire Colubridae to be arranged alphabetically to facilitate location of a species by anyone (like myself) not familiar with subfamilial classification.

The book suffers from a few production errors and editorial oversights. On many of the range maps the shading which shows the species' distribution is too faint to make out easily. Specific epithets are capitalized at the head of each species account. Superscripts and subscripts are not well printed. The colour photo of *Tropidoclonion* is labelled *Thamnophis*. There are several typographical and grammatical errors.

All in all the book is not up to the quality of the authors' previous works (Ernst and Barbour 1972, 1989). *Turtles of the United States* (1972), is a well-produced book which treats 49 species in 347 pages, whereas this book covers 58 species in 282 pages. However, given the enormity of the task and the amount of material which is covered in the book, its advantages outweigh the drawbacks.

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Ernst, C. H., and **R. W. Barbour.** 1972. Turtles of the United States. University Press of Kentucky. 347 pages.

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Ross MacCulloch

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Arizona Game Birds

By D. E. Brown, University of Arizona Press and the Arizona Fish and Game Department, Tucson, Arizona. 307 pp., illus. U.S. $19.95.

This book is written by an enthusiastic hunter for other hunters who want to know more about their prey. As the author displays a profound sense of enjoyment in the outdoors I do not believe his sole objective is to make his readers better hunters. The information given and the style in which it is presented make it more useful than a hunting guide.

I divide bird books into three categories. The first group contains the basic guides, not only for species identification but also those that tell you

where and when to go and what you can expect. These books are basic essentials for both naturalists and hunters. The next group are those that go beyond the basics to give more detailed information on some narrower aspect of birding. This book falls into this category. The final group is scientific text.

The author covers eight species of quail, grouse etc., three species of dove, and Sandhill Crane. I was surprised to find the latter listed as a game bird (I have seen many European Mediaeval recipes for "crane" but assumed they referred to herons. These disappear as the domestic chicken became more widespread). I now know that not only is the Sandhill Crane legally a game bird but there are open seasons in two provinces and 20 states. The annual Canadian harvest is several thousand.

The author uses a pleasant, readable style and I enjoyed reading the sections on habitat, ecology, life history, and populations. There are some excellent range maps and both line drawings and black-and-white photographs. Naturally, he also covers the management practices in Arizona, especially as they relate to hunting. I have to ask why they tried so hard and so often to introduce foreign species; surely these birds are not any better to hunt than native species. Not being a hunter I found the sections covering the author's hunts less appealing and somewhat repetitive (like reading old accounts of Gretzky's goals). Similarly, using internal organs to sex a bird is of more value to a hunter than a birder.

Despite the book's orientation I found most of it interesting and useful reading. I would recommend it to any birder, who like me, has great difficulty finding those elusive Arizonan quail, and to those who simply want to learn more about this enjoyable group of birds.

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Birds of the Eucalypt Forest and Woodlands

Edited by A. Keast, H. Recher, H. Ford, and D. Saunders. Surrey Beatty and Sons, New South Wales, Australia. 384 pp., illus. A. $47.00 plus postage; U.S. $43 inclusive.

This work has some fine illustrations, is printed on glossy paper, and externally appears to be a coffee-table art book. But in reality it is a selection of 31 scientific papers by 30 authors. Some are difficult to read if you are not aware of the terms used in Australian ornithological science. The papers cover three basic areas: bird communities, ecology, and human impact. In general the writing styles are compatible and clear making it one of the more easily read scientific texts. The authors have made extensive use of graphs and charts; an invaluable way to convey one's hypothesis.

One paper can serve as an example of what the book offers. "Bird Populations of a Logged and Unlogged Forest Mosaic at Eden, New South Wales" by Kavanagh et al. addresses a question that has long intrigued me. Unfortunately their results are disappointing. Despite the fact that loggers left a significant area of forest intact and cut trees in alternate blocks (a mosaic pattern), there was a sharp decline in both species and numbers. It is clearly a better method than clearcutting, but large tracts of undisturbed woodlands must remain if we are to maintain our ecosystems.

The book has several full-colour, full-page illustrations depicting some of the forest's most colourful inhabitants. Almost as colourful are their intriguing names. Who can fail to be attracted by Clinking Currawong, Beautiful Firetail, Gang Gang, and Noisy Miner. In addition there are many black-and-white drawings scattered throughout the text. All this art work is both technically competent and aesthetically pleasing.

It is interesting to note that this text was suggested and promoted by a professor at a Canadian university (Allen Keast, Queen's University). It came about as the aftermath of a congress of the Royal Australian Ornithologists Union in 1982, with additional papers to add some missing depth. For those willing to look up some unfamiliar genera there is an intriguing glimpse of a very un-Canadian habitat.

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Encyclopedia of the Animal World. Volume 6, Birds: The Aerial Hunters; and Volume 7, Birds: The Plant and Seed Eaters

By Martyn Bramwell; and by Jill Bailey and Steve Parker. 1989. Facts on File Inc., New York. Each 96 pp., illus. Each U.S. $17.95; $21.95 in Canada.

For young people, who are used to synopses of vital statistics, bare facts, and instant information, these two volumes will serve admirably. They are two in a series of 12 *Encyclopedia of the Animal World*, of which there are 4 volumes on mammals, 3 for birds, and single volumes for reptiles, fish, insects and spiders, simple animals, pets and farm animals.

Any parent trying to help with a school project knows how difficult it is to find source material at the 10-13 age level - there are plenty of encyclopedias for young people, but few of them are devoted solely to natural history.

Judging by these 2 volumes, this encyclopedia may fill a need. The authors have divided birds into 3 groups: Waterbirds, Plant and Seed-eaters, and Aerial Hunters. Within these groups, each genus is described in two or three pages and the most photogenic and colourful are illustrated. The brief text tends to concentrate generally on the most interesting behaviour characteristics, which is probably an admirable format to catch the attention of a youngster reading about birds for the first time.

The species are unevenly covered, two whole pages are devoted to the hoopoe (8″ of text) compared to 11 inches of text on the large and world-wide flycatcher family. However, the vital statistics given in the "Fact Panel" at the beginning of the genus description are a good summary, and by pictograms show: activity time, group size, conservation status, diet, breeding, and habitat. Maps show the distribution over the world but a few are inaccurate; e.g., no Starlings in North America! The drawings and photographs are very good and the colour reproduction is excellent.

Readers are given a list of other reference books on ornithology to consult for more serious study. Each volume contains two good indices, one giving common names, the other the scientific, Latin name of each species. If the other 10 volumes are similar, the whole encyclopedia could form a basic natural history library for a child or school library.

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Turtles of the World

By Carl H. Ernst and Roger W. Barbour. 1989. Smithsonian Institution Press, Washington. xii + 313 pp., illus.

According to Ernst and Barbour, there are 257 living species of turtles. Although the exact number will be a subject of debate among turtle systematists, it is nevertheless sufficiently small to allow the authors of this book the luxury of writing detailed individual accounts of all species that they recognize, in just over 300 pages. Attempting to do this with almost any other vertebrate group of equal taxonomic rank would result in an impossibly large book. This species-by-species coverage is an attractive feature of this volume and I suspect that every turtle enthusiast will want a copy. Even so, it will be useful mainly to the serious student, whether amateur or professional; those who want a general introduction to turtles would do better to go elsewhere.

The first chapter of this book jumps immediately into very technical material that likely will not appeal to the layman. This chapter, on the Order Testudines, covers morphology, taxonomy, and palaeontology. We are exposed to strange sounding taxonomic ranks such as gigaorder, hyperorder, and parvorder, but there is nothing on aspects of the general biology of turtles such as reproductive habits, temperature-dependent sex determination, diet, hibernation, etc. (although there are references to these in various species accounts).

This is a book that you look things up in, not one that you casually read in bed (I tried). Its organization is straight-forward. Each family of turtles is introduced with a general description (mainly morphological) and a map showing its worldwide distribution. Each genus is described and individual accounts of species within that genus are given. Ernst and Barbour also provide keys to the families of turtles (one for each megaorder), followed by keys to genera and species. These keys are supplemented in a very few places by tables comparing features of related taxa, but illustrations to aid in identification are absent. I used the keys to identify one specimen each of *Trachemys scripta, Terrapene carolina,* and *Chelydra serpentina*, and found it helpful that I was already familiar with turtles (not to mention

that I already knew what species I had in each case). Diagrams illustrating alternative character states would have been helpful in places.

The species accounts are divided into various headings, not all of which appear in every account: Recognition, Distribution, Geographic Variation, Habitat, and Natural History. Length of species accounts varies greatly, depending on how much is known, and research needs and uncertainties about systematic position are identified. There are frequent references to the literature and to unpublished observations of the authors and their colleagues. A black-and-white photograph accompanies most species accounts, and 55 species are shown in 16 colour plates in the middle of the book.

Rounding out the book are a Bibliography, a Glossary of Scientific Names, and an Index. The list of references is comprehensive, especially in systematics and zoogeography, but less so in ecology. I especially liked the inclusion of relatively obscure references like Master's theses. The Index covers taxa only, which is a bit frustrating if one wants to look up words like "arribada" or "neustophagia". These are defined in the text, but finding the definition is a bit hit-or-miss. Even more obscure to most readers will be the term "fall line"; I had to go to a paper by Tinkle in 1959 to look that one up.

Given the nature of much of the material, the text is necessarily dry, but it is still rewarding to read. The book's greatest strength is in the area of systematics, but it does offer some interesting tidbits of natural history as well. I was interested to learn that *Chelodina longicollis* may exhibit colour-matching of its background, that male *Geochelone yniphora* (and other tortoises) attempt to overturn females while courting them (but why?), and that there is a non-swimming population of the normally aquatic *Mauremys caspica* in Iraq. The description of courtship in *Psammobates oculifera* struck me as hilarious. Other accounts are more depressing (e.g. the sad status of several species of Galapagos tortoises). I was pleased to see that the authors made use of observations of captive specimens wherever possible to supplement field data. Evidently, they have personally seen virtually every species in this book because they make a point of noting the very few exceptions.

Although I would have liked to read more about the ecology of turtles and perhaps learn something about their physiology (untouched here), a book like this cannot cover everything. The book is well written and nicely laid out. I could find very few typographical errors ("hyoplastron" is spelled "hypoplastron" in the figure on p. 4, "Stoneburner" is spelled "Stonebruner" on p. 125, "Juvik" is spelled two different ways on p. 253, "the key below" on p. 257 is actually on the previous page). However, these are minor and do not detract from the overall value of the book. I recommend it to all serious herpetologists.

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Reptiles and Amphibians

By John Stidworthy (with contributions by Jill Bailey). 1989. Facts on File, New York, 96 pp., illus. U.S. $17.95; $21.95 in Canada.

There are a lot of books that provide a general introduction to the biology of amphibians and reptiles. This one is classified as "juvenile literature". Because the first author (PTG) of this review is no longer a juvenile (at least in terms of age), and therefore lacks the perspective to assess this book from that angle, he recruited the assistance of JSG, a normal, reasonably well-read, 10-year-old, with a somewhat better-than-average knowledge of amphibians and reptiles.

This book is part of a 12-volume series entitled *Encyclopedia of the Animal World*, which is endorsed by the National Wildlife Federation (U.S.). This particular volume is organized mainly along taxonomic lines. After a brief Introduction, there is a general chapter on amphibians, followed by chapters on particular groups of amphibians, then a similar treatment of reptiles. The book ends with a brief Glossary, two Indexes (one of scientific names, the other of common names), and a Bibliography.

Probably the most striking aspect of this book is its remarkable similarity to an earlier book from the same publishers, *The Encyclopedia of Reptiles and Amphibians*, edited by Tim Halliday and Kraig Adler (1986). This is especially true of the excellent photos, drawings, and distribution maps, most of which are identical to those in Halliday and Adler. Furthermore, the two books are also organized in much the same way, and Stidworthy's text often seems to be a scaled-down version of that in Halliday and Adler. Both books are very colourful. The only obvious difference between the

two is that the latter covers more topics (e.g. extinct groups) and treats everything in much greater depth.

Halliday and Adler's book is an inexpensive and good general reference work, even for children. Why then would anyone buy Stidworthy's book instead? The answer is that younger children probably will like it more. JSG though it *looked* more like a kid's book and liked the bigger printing. She also liked the coloured symbols used in each chapter to summarize habitat, diet, etc. (PTG found it frustrating to keep turning back to the legend to look them up, but he's a stick-in-the-mud). Other features that will appeal to children are the brief, paragraph-long "stories" that start each chapter, and the too brief "Amphibian Facts" and "Reptile Facts" that list the biggest, smallest, most poisonous, etc. JSG found the text fairly easy to read, although she needed to consult the glossary or dictionary at times.

The factual content of this book is fairly solid, notwithstanding Stidworthy's claim that ancient amphibians were overcome by dinosaurs. Some of the writing is a bit misleading, however. For instance, we read, in reference to lizards, snakes, and wormlizards, that ". . . some still have pelvic girdles in their skeletons", as if limblessness were characteristic of most lizards. Contradictory statements are made in places: the caption under the picture of the chameleon on page 35 suggests that these lizards change colour to match their background, but on page 50 we learn that other factors influence colour change in chameleons. PTG's main complaint about the book's content is its unevenness, and lack of background information. For example, few parents, let alone their children, will understand the simple phylogenetic tree of amphibians on page 9 both because it lacks labels on the axes and because it assumes knowledge of what evolution is all about. (JSG certainly did not understand it.) Lateral line organs are mentioned on page 17 without indicating that they detect pressure changes, and are not even pointed out in the exceptionally clear photograph of a Congo eel on page 19. The glossary seems to be no more than a list of words hastily written down without any thought to completeness or appropriateness: "frog", "toad", "salamander", "turtle", and "tortoise" are all listed in the glossary, but "caecilian", "snake", and "lizard" are not; "plastron" is included, but "carapace" is not; "spermatophore" is defined, but not actually used in the text.

Presumably in the interests of brevity, not all amphibian and reptile groups are covered in this book, but the way in which they are combined or not seems arbitrary. Congo eels and sirens, which are not closely related, are covered under one heading, but separate coverage is given to alligators and crocodiles, and to pythons and boas. The index is adequate, but it covers only taxa; JSG would have liked to be able to find words like "tadpole" and "fang". The bibliography is reasonable but leans too much towards the technical literature. There seem to be few, if any, typographical errors.

PTG was initially sceptical about the need for this book and is still of the opinion that it could be improved in many ways. However, JSG's greater enthusiasm eventually convinced him to give it a passing grade. If Stidworthy's effort interests children in learning about amphibians and reptiles, it will make a useful contribution to natural history education.

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Crocodiles and Alligators

Edited by C. A. Ross and S. Garnett. 1989. Facts on File, New York. 240 pp., illus. U.S. $35.00.

Thirty one authors from eleven countries, many of them specialists in the study of crocodilians, have contributed to this informative book. This work is impressively illustrated with more than 250 colour illustrations as well as a number of old monochrome photographs illustrating virtually every aspect of crocodilian natural history.

This book is divided into three sections. The first one, "Evolution and Biology", includes four chapters: "The place of crocodilians in the living world"; "Evolution"; "Structure and function"; and "Living crocodilians". The latter illustrates in colour each of the 22 species of living crocodilians, briefly describing its appearance, habitat, distribution, reproduction, and diet. A small distribution map for each species is included as well. The second section, "Behaviour and Environment" includes five chapters: "Food and feeding habits"; "Mortality and predators"; "Social behaviour"; "Reproduction"; and "Habitats". The final section, "Crocodiles and Humans", is made up of six chapters: "Mythology, religion, art, and literature"; "Attacks on humans"; "Crocodile-skin products"; "The trade in

crocodilians"; "Farming and ranching"; and "Conservation and management". Following this is a checklist of living crocodilians, a bibliography, acknowledgements, notes on the contributors, and an index. The Bibliography is short, approximately one double-column page, but, as is pointed out, much of the information within this book is derived from original research by the contributors.

Within the chapters are many one-page contributions by various authors on particular aspects of crocodilians, for example, "Birth defects in American Alligators", "Efficient metabolism", "Vocalizations", "Mummified Egyptian crocodiles", and "Safety precautions for visitors to crocodilian areas", to mention a few.

I noticed few minor errors. The photo caption on page 17 refers to the Tuatara as a lizard, which it is not. However in the text, this animal is referred to correctly. Although not really an error, Johnston's Crocodile is referred to throughout this book by the originally published misspelled name, *Crocodylus johnsoni*. Many authors now use the emended name, *Crocodylus johnstoni*. The emended name of the American Alligator, *Alligator mississippiensis*, however, is used. I would like to have seen identification keys, and perhaps more information on anatomy and physiology, but these areas are of questionable relevance in a publication intended for more general readership.

These are only minor quibbles, scarcely worth mentioning. This is indeed an excellent book with up-to-date information and I heartily recommend it to all who wish to know more about these "last remnants of the great age of reptiles".

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The Coyote, Defiant Songdog of the West

By Francois Leydet. Revised edition. 1988. University of Oklahoma Press, Norman. 224 pp., illus. cloth U.S. $19.95; paper U.S. $8.95.

I was delighted by the request to review an updated version of Leydet's 1977 classic book on the coyote. My delight was lessened to find that this edition was merely a reprint of the earlier work with an addition of nine pages to describe new findings between 1977 and 1988. However, the book is still fascinating reading for anyone interested in coyote behaviour, predator control and human attitudes toward wildlife. The title is too lurid for my taste but that should not be a deterrent to reading this book. It is written in a non-scholarly fashion to carry its thoughtful message to as wide an audience as possible.

In asking the central question of the book "Why can one human exult in the life of this animal while another calls for its destruction", Leydet comes down clearly on the side of the coyote. His delight for the life of the animals he writes about is infectious but does not blind him to the emotions he discovers in those who would destroy the species as an economic competitor. Leydet makes it clear that the coyote is not an endangered species. It has proven much too adaptable for humans to eradicate. He clearly states that this is not a definitive work on the coyote but more of an exploration of human attitudes toward coyotes. It is also a discussion of the coyote relative to the United States, not Canada.

He begins to set the scene for his discussion of human attitudes in his second chapter where he attempts to portray predation in an objective light, focusing at the heart of our preconceptions and misconceptions about predation. He discusses the coyote as a predator arguing that the act of predation is neutral in feeling; coyotes no more "hate" their prey than humans do in slaughtering a cow for its meat. He argues that we attach too many human values to animal behaviour.

His third chapter describes events in the life of a litter of coyote pups from the perspective of the coyotes. He acknowledges that he is treading on dangerous anthropomorphic ground in adopting this approach but uses it to provide information on observable coyote behaviour within the context of the animals' total environment.

Having provided a portrait of life in a coyote group, Leydet reviews the evolutionary lineage of coyotes and native North American perceptions of coyotes as exemplified through their myths and stories.

Leydet moves on to the coming of Europeans to North America and the first European exposures to coyotes. Mass exterminations of predators were carried out in the American Midwest through massive government controlled and sponsored poison programs. No serious voice of dissent against these policies was heard until the 1930s. Leydet describes the continued poisoning programs and the extensive efforts undertaken to

eradicate coyotes from the American Midwest and also the reasons for the failure of such programs, not the least of which is the extreme adaptability of the coyote to even the severe pressures humans can bring to bear.

One of the messages of this book is that obsolete, outmoded "management" programs, such as the massive 1080 poisoning programs, can be replaced. That uplifting message is shattered by a second message that wildlife management tends to mean "for human use". Unless a species has economic value, it becomes a pawn in the web manipulated to control other species. Aerial hunting was one of the techniques that replaced the 1080 poisoning programs. Leydet's descriptions of actual hunts and the attitudes of those who conducted the hunts provide a chilling perspective on humans as predators.

As a reviewer's aside, Canadians need not feel superior to Americans in their handling of large predators or attitudes toward competitors. Note that we are being asked to support the killing of bison in a national park (remember national parks where species are "protected in perpetuity"?) to support the expansion of an already heavily subsidized cattle industry onto what is surely the most marginal of lands for cattle production. We kill wolves and coyotes in an effort to make more moose, more caribou, more deer, ironically for a declining population of human hunters.

Leydet's final chapter reminds us all to reread the writings of Albert Schweitzer on the value of life and the need to understand the context of our actions within a philosophical framework. Leydet's parting message is unequivocal: we are not in a moral position to condemn predators for taking a share of a valuable resource (such as livestock) while we continue to remove non-renewable resources at an ever accelerating rate. We are a species addicted to quick, easy and often violent solutions to our problems. Humans must change their fundamental thinking on their role, rights and responsibilities. He reminds us of George Small's question in writing about human atrocities toward the Blue Whale, "What is the nature of a species that knowingly and without good reason exterminates another?" and asks us to accept Loren Eiseley's plea, "The need is not really for more brains, the need is now for a gentler, more tolerant people".

The book ends with an appendix summarizing research on coyote management between 1977 and 1988.

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Bites and Stings: The World of Venomous Animals

By John Nichol. 1989. Facts on File, New York, 207 pp., illus. U.S. $19.95, $25.95 in Canada.

Many people and many cultures have a love-hate relationship with venomous animals and that is the topic explored by John Nichol in this popularized book. All the major groups of animals with the potential to inflict serious damage to man by bites or stings are covered and the scope of the book is world wide.

Several scorpions and snakes are famed for their ability to inflict pain or worse. What is not so generally well known is that many other kinds of animals also would bite or sting us if provoked or, as in the case of amphibians, emit poisonous substances through their skins when handled. Nichol explores how and why these animals employ their venoms and the varying physiological properties of these substances and their actions on us. The animals included are two mammals, several fish, amphibians, echinoderms, coelenterates, molluscs as well as the expected complement of insects and spiders. Nichol points out that relatively few animals are a threat to us and attempts to allay our fears of venomous animals by showing that these animals aim their poisons at potential food sources (almost invariably non-human) or for self defense. Most of these animals would rather flee us than fight.

Biting flies are omitted because the author considers them only to be transmitters of other disease organisms. Yet they do have venoms in their salivas causing much irritation and itching as many of us can testify to.

If knowledge affords some protection, then to learn of possible venomous hazards before venturing into unfamiliar terrain is a wise move. Such potential hazards, worldwide, and their antidotes — if recorded — are covered in some detail in this book. The section on first aid is a little sketchy and not likely to be very useful but the complete list of suppliers of antivenoms, worldwide, may be useful to the afflicted traveller and is presented in the appendix. That alone might make this book worth packing on field trips to tropical countries where Canadians are most likely to come in contact with unfamiliar venomous animals. The very gory details of some unfortunate biting encounters may titillate the fancies of some but I think they will add to the aversion others have for these animals.

How various religions have incorporated venomous animals in their symbols and rituals and some of the myths and legends surrounding these animals are also explored in this book.

Rearing of venomous animals is discussed as are the many regulations surrounding such enterprises. Nichol points out that because these animals have a bad press even zoos have decreased or curtailed their poisonous animal holdings. For the interested conservator of such species a list of organizations and publications devoted to the rearing and maintenance of these animals is given. They are most vulnerable to extinction and probably more in need of careful, controlled rearing.

It is a pity that this book too, like several others published by Facts on File, suffers from a lack of editing. Several sentences are poorly constructed and ambiguous in meaning. There is a beautiful coloured plate of a moth mimicking a hornet (page 88) but the legend does not identify it as the mimic. Generally the coloured photographs are superb but most of the black-and-white photographs are mediocre at best. The illustrations are not always well-coordinated with the text. For all that, it is a rather unique book with its focus on the venomous animals and the antidotes to these venoms and the legends surrounding the animals.

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Bears of The World

By Terry Domico. 1988. Facts on File, New York. xv + 189 pp., illus. U.S. $29.95; $39.95 in Canada.

In this attractive, non-technical book, Domico surveys the ecology of bears throughout the world. Chapter One sets the stage for the rest of the book with a synopsis of the general ecology of the bear, including evolution, morphology, parasites, eyesight and smell, intelligence, food strategies, home range, hibernation, reproduction, and behaviour. I was pleased to see some space devoted to dispelling the myth that bears have poor eyesight.

Chapter Two focuses on the American Black Bear, and in addition to reviewing its life history characteristics, Domico describes some of the behaviours this species employs to deal with man, particularly in conflict situations. Chapter Three is devoted to brown bears, including the Grizzly Bear, the bears of Kamchatka, the Japanese Brown Bear, and the European Brown Bear. There is a section on human interactions with the Grizzly Bear, and as is the case in many of the chapters, the author provides comment and insight from some of the leading bear researchers and management biologists.

In his review of the Polar Bear, Domico examines its recent evolution, life history characteristics, and conservation initiatives. Part of the chapter is devoted to a review of the situation at Churchill, Manitoba, a northern Canadian community which has learned to live with the big white bears which inhabit this part of the Hudson Bay coast during the warm months of the year. Bear management and research programs in the Churchill area are described.

Chapter Five focuses on the Sun, Sloth, and Spectacled bears of the world's tropical regions, while Chapter Six concentrates on the Asian Black Bear. The Panda Bear is the focus of Chapter Seven, and includes a review of conservation efforts to save this bear from extinction.

"Living With Bears" is the theme of Chapter Eight. It begins with a succinct review of how ancient cultures perceived and valued the bear. Problems are identified in various parts of the world and various management techniques and research programs are reviewed, including aversive conditioning, handling, and trapping techniques. Domico identifies major conservation issues relating to habitat decline (eg. deforestation), poaching and over-hunting, commercial markets, and human-bear conflict.

The last chapter is entitled "Safety in Bear Country". Domico addresses the importance of understanding bear behaviour to management and to the reduction of human-bear conflicts, techniques for the safe storage of food, what to do in the event of an encounter with a bear, and bear deterrents (eg. nonlethal plastic slugs). This chapter is very useful to those living and working in bear country, but I must continue to recommend that readers interested in a thorough review also consult Dr. Steven Herrero's book *Bear Attacks: Their Causes and Avoidance* (See Canadian Field-Naturalist 101(2): 312-313).

The book is loaded with many beautiful photographs of the world's bears and their habitats. Range maps, a list of suppliers of non-lethal bear deterrents, a list of recommended reading materials, and an index are also included. I enjoyed this book and recommend it to all who are interested in the general ecology and management of bears found throughout the world.

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A Guide to the Birds of Panama with Costa Rica, Nicaragua, and Honduras

By Robert S. Ridgely and John A. Gwynne, Jr. 1989. Second edition. Princeton University Press, Princeton. xvi + 534 pp., illus. U.S. $49.50.

Panama, with 929 species, has 12 species per 1000 sq km, and Costa Rica, with 833 species, has 16 species per 1000 sq km. These two countries have more birds for their size than any other country. So they are visited by many birders from around the world. (Canada has 0.06 species per 1000 sq km). Ridgely's 1976 Panama guide has long been *the* book to use in Central America. That remarkable seminal work set a revolutionary new standard for field guides which must deal with an immense avifauna. The style has been widely imitated, most successfully in Hilty and Brown's *A Guide to the Birds of Colombia.*

In this expanded and improved second edition, full treatment is now given to 1091 species, compared to 883 in the first edition. The sequence and taxonomy has been revised and updated to follow the 1983 AOU Checklist and supplements. (This is in sharp contrast to Stiles and Skuth's concurrent *A Guide to the Birds of Costa Rica* which kept the "old" sequence and taxonomy of the 1957 Checklist).

The main section of the book deals with 929 species of Panamanian birds. This part now has 40 plates (11 new ones, and 29 of the 32 in the first edition). Much new information has been added on the status, distribution and habits (especially songs and calls) of many species. Robert Ridgely is one of the finest field birders in the world, and his personal knowledge and field skills are happily matched with a clear, graceful writing style.

Each family, or occasionally sub-family, is introduced by a general account emphasizing distinctive family characteristics. The species accounts begin with a description. It is a pity that the lengths are still given only in inches. The descriptions are remarkably clear and yet economical, omitting details not useful for identification. A section on similar species is included for almost all species. (Stiles and Skutch omit any discussion of similar species!) The status and distribution of the species in Panama is given in considerable detail. A section on habits includes behavioural information and careful transcription of vocalizations, so important to bird identification in the tropics. The overall range of each species is stated briefly. Many species accounts include a note on the taxonomic status of the species, or of similar species not yet recorded from Panama, but whose known ranges closely approach Panama either in Colombia or Costa Rica.

The treatment of 162 additional species of Costa Rica, Nicaragua, and Honduras is placed in a separate 38 page section plus 8 new plates. This new section is a huge improvement over the first edition which merely listed some adjacent Central American species from Costa Rica, etc., gave their ranges and, rarely, a brief description. The new plates here, and in the main section, show that John Gwynne is now a truly fine artist, whose birds look very much alive. His new Plate 43 of additional hummingbirds is absolutely superb.

All in all, this book is a triumph — a vastly improved classic!

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Rare Birds in Britain and Ireland

By J. N. Dymond, P. A. Fraser, and S. J. M. Gantlett. 1989. Buteo Books, Vermillion, South Dakota. 366 pp. illus. U.S. $55.00.

The search for rarities is the impetus behind much of birding, and they are the source of endless fascination. Committees adjudicate on them, nature clubs chronicle them, phone networks report on them and thousands of hours and dollars are spent chasing them.

Now the British have this well-produced volume, a major consolidation and updating of earlier compilations in 1974 and 1976. It gathers together all the records of over 300 "rare and scarce migrant birds" that have been recorded in the U.K. and Ireland between 1958 and 1985. Each species has its range and key field characters briefly summarized with a reference giving further information, together with a line drawing of the bird. The more regular species then have their status outlined, supported by histograms; one showing the total occurrences in each year over the period covered, the second showing seasonal occurrences by weeks over the course of a year. Supporting these are two maps, showing total occurrences by county for spring and fall. For the rarest birds (12 or fewer occurrences) the individual records are enumerated by county, location, and date.

This represents a formidable undertaking. Some 43000 published records have been reviewed and

analysed by computer. Some major logistical problems have had to be overcome; changes in political boundaries (the old counties are retained), changes in procedures of record keeping, and the enormous expansion of birding activity over the period.

Was it worth all the effort? I think the answer is very clearly yes: the data presented give a coherence to a multitude of isolated observations, and reveal patterns that are often wholly obscured in the month to month and year to year turmoil of fieldwork. It will be particularly valuable to its main audience, the British birders, in displaying the frequency and timing of vagrant occurrences. Patterns of occurrence can now readily be identified, providing a basis for further investigation: as with all such initiatives, the book will raise as many questions as it answers.

There are some weaknesses. For example, I wondered how many of the cardueline finches had occurred in flocks, and I am still not sure. The vignettes are uneven in quality: the artists' lack of familiarity with some of these species is clear, and some sketches are simply inaccurate. Generally, however, the work is a thorough, well-produced and attractive publication.

The book's value to a North American audience is rather limited and the book is expensive for its potential uses. The records of North American species on the other side of the Atlantic make fascinating reading, and the concise summaries of identification characters could be useful, as in the case of Eurasian pipits. The approach will be of interest to Records Committees considering publications, and students of vagrancy and migration will find the material an excellent source of reference.

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Where Have All the Birds Gone?

By John Terborgh. 1989. Princeton University Press, Princeton, New Jersey. 207 pp., illus. Hard cover U.S. $45.00, Soft cover U.S. $14.95.

The subtitle of this stimulating book, *Essays on the biology and conservation of birds that migrate to the tropics*, provides a good summary of its contents. Other groups of birds are dealt with, but primarily to clarify the main thesis of the book - that many neotropical migrants are threatened by human activities under way throughout their range. The author pulls together the admittedly rather scant data available to illustrate the mechanisms by which some neotropical migrants, most notably forest-dwelling species, are suffering, and the extent of the problem.

In outlining the current information base, Terborgh includes a useful discussion of bird population monitoring in North America. He credits the amateur naturalists who make feasible the Christmas Bird Counts, Breeding Bird Census, and Breeding Bird Survey, and who provide some of the best data available on the distribution, abundance, and habitat selection of species. However, he is critical of the methodologies of these surveys, stating that "it is time that these efforts be overhauled to accord with the best available scientific methods." He laments both the lack of long-term monitoring projects that would offer much-needed understanding of changing bird populations, and the lack of virgin timber stands that would provide the baseline data needed for comparison.

Terborgh's contention that "Conservation is essentially a debate over land-use policy" is borne out through examples of how land-use affects bird populations throughout the Americas. The destruction of the eastern deciduous forests in the 19th and early 20th Century is described along with the current destruction of neotropical forests. Somewhat ironically, he suggests that the earlier destruction of the eastern forests so devastated the breeding populations of forest-dwelling neotropical migrants that the effects of forest clearing in the neotropics may not be noticed in North America for another 10 years: for the moment, there is still forest habitat enough for the relatively small numbers of most species returning to the tropics each winter. Given current trends, the declining area of tropical forest might be the limiting factor in some North American bird species by the turn of the century.

Where have all the birds gone? is readily accessible and highly recommended to scientists, naturalists, and conservationists. A useful summary of the current state of our knowledge of changing bird populations, it is also a call to arms. Its intent is to encourage immediate action by scientists and conservationists; "if we wait until all of the answers are in, we may find ourselves in a much worse predicament than if we had taken notice of the problem earlier." The book's final chapter explains what each of these groups can do to help prevent the further loss of neotropical migrant birds. It deserves to be widely read and acted upon.

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The Freshwater Fishes of Europe, Volume 9: Threatened Fishes of Europe

By Anton Lelek. 1987. AULA-Verlag, Wiesbaden, West Germany. 343 pp., illus. DM236.

This volume covers 19 families of European freshwater fishes with 107 species and subspecies having accounts out of a total of 200. There is no explanation why some species are omitted. Some omitted species are common while others are of restricted distribution. One can only assume there is a lack of data for these particular species.

Each considered species is placed in a classification "Endangered", "Vulnerable", "Rare", or "Intermediate". The definitions vary in details from the IUCN Red List categories. For example "Endangered" includes "those supposedly extinct". Twenty-five species are classified as "Endangered".

The species accounts include scientific and common names, threatened classification, distinguishing characteristics, worldwide distribution, distribution in Europe, ecology, population in Europe, reasons for decline, conservation measures taken, and conservation measures proposed.

A section at the end of the species accounts gives conservation proposals but is only six pages long. There is a short bibliography in which many of the papers are systematic, ecological, or distributional. Few specifically address the problems of conservation in European fishes or provide evidence of detailed studies having been carried out on threatened species. This lack of knowledge is reflected in the text. Very few species have specific explanations for declining populations other than general comments on environmental change. Canada, in contrast, has been well-served by the Committee on the Status of Endangered Wildlife in Canada. Their reports are much more detailed and field studies on various species have been funded to generate new and accurate data. Twenty-four Canadian fishes have been assigned a classification by COSEWIC, a further 30 are under review and a further 57 are listed as a potential interest. In contrast, the 1988 IUCN Red List of Threatened Animals mentions only one fish species from Europe.

No species are illustrated. There are 94 species distribution maps. These are mainly shaded and give a general idea of European distribution. Some spot maps are misleading. The map for salmon on page 98, for example, has regularly spaced dots along the northwestern coast of Europe and cannot refer to collection records, the usual interpretation of a dot map. Given the long history of angling and fisheries research in Europe, surely it would have been possible to construct comparative maps of distribution over time as a vivid depiction of change.

The text is replete with spelling errors and not all papers referred to in the text appear in the Bibliography.

This book is the last volume of a series of which two others had appeared by mid-1990, Volume 1/I: Petromyzontiformes and Volume 1/II General Introduction to Fishes. Acipenseridae. It is based on a 1979 manuscript and the author admits that it was not thoroughly updated and that reference should be made to other volumes in the series. The previous two volumes contain more references, in some cases, for a single species than are given for all the 107 species covered here. Much of the text of the present volume is superfluous since classification, characters, distribution, and ecology are to be covered in the other volumes of the series or are readily available in other works. The economic importance sections of the first two volumes in the series have a much more detailed account of the status of the species they cover. This book should have been written last, benefiting from the detailed accounts in the other books in the series. It would then have been a convenient summary of the status of threatened fishes in Europe based on recent information. As it stands, it is out of date and can serve only as a cursory starting point for information on European threatened fishes.

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Birds of the Seward Peninsula, Alaska: Their Biogeography, Seasonality, and Natural History

By Brina Kessel. 1989. University of Alaska Press, Fairbanks. 330 pp., illus. U.S. $34.95.

Before her first visit to the Seward Peninsula in 1966 the author was aware of the significance of the area for avifaunal studies. Its position on the west-central coast of Alaska made the Peninsula important to migrating and breeding birds from at least four continents. The area's variety of habitats, from open saltwater to dry alpine summits, suggested an impressive diversity of species. In fact over one-half of all species known to occur in Alaska have been found on the Seward Peninsula. And the zoogeographic affinities of the Peninsula,

due to its proximity to Eurasia, could contribute to a better understanding of the effects of the Bering Land Bridge to Alaskan as well as North American avifauna.

The author started her investigations in 1967 unaware that during the next decade the Seward Peninsula would become the focus for state seabird and raptor inventories, environmental impact studies, and graduate student research. It would also become better known and more accessible to birdwatchers. What started as a well-defined, short-term research project quickly developed into a full time job keeping up with the deluge of new information. Twenty-three years later Brina Kessel has produced a comprehensive, well-researched, and up-to-date treatise on the birds of the entire Peninsula.

The area covered by this book includes the entire land mass of the Seward Peninsula, an area nearly one-half the size of New York State. The Peninsula forms the eastern edge of the Bering Strait which separates the Bering and Chuckchi seas. It is immediately opposite the Chukotsk Peninsula of the Union of Soviet Socialist Republics.

The book is divided into nine main sections of which five are introductory chapters and form a valuable feature of the book. The physiography, climatic features, and other environmental factors such as tidal activities, sea ice, and winds comprise one chapter which ends with a very general overview of the vegetation of the Seward Peninsula. The next chapter discusses 21 major habitats on the Peninsula following the classification system for avian habitats in Alaska developed by the author (see *Murrelet* 60:86-94;1979). It is adequately illustrated with 17 black-and-white photographs which, unfortunately, are the only photographs in the entire volume.

The most controversial chapter includes 11 pages on avian species abundance. Between 1967 and 1977 the author simply recorded total numbers of each species seen in summer during a total "transect" of nearly 3000 km by foot, automobile, and boat. In addition 320 stationary counts were made over representative habitats. Since bird numbers are used in so many discussions today involving environmental impact studies, habitat assessment and enhancement, and population ecology, census methods must be accurate, well-defined, and repeatable in the future. It is unfortunate that standard sampling methods were not incorporated into the study (see *Studies in Avian Biology* No. 6; 1981). In fairness to the author, however, she warns the reader that "actual numbers listed . . . are meaningless in themselves; they are included solely for their comparative significance." So we learn that the most numerous species on the Seward Peninsula are the Northern Pintail (waterfowl), Western Sandpiper (shorebirds), Glaucous Gull (Larids), and Common Redpoll (passerines). The Lapland Longspur is the most abundant species in shrub habitats and along with the Snow Bunting occurs in most numbers in alpine tundra areas. In wetland habitats Northern Pintail, Glaucous Gull, Red-necked Phalarope, and Red Phalarope are the most numerous bird species. The table on seabird populations is the most useful and reliable reference in this section.

Another chapter, only seven pages in length, presents the zoogeographic affinities and contemporary distribution patterns of birds on the Seward Peninsula. It is generally known that during the Tertiary Period (10-75 million years ago), when modern bird families were evolving, North America and Eurasia were joined by the Bering Land Bridge. This 2000 km land mass actually formed part of the Seward Peninsula. Kessel suggests that of the ". . . regularly occurring breeding birds and visitants on the Seward Peninsula . . ." nearly half (47%) are of North American derivation. Some of these species include Common Loon, American Wigeon, Solitary Sandpiper, Tree Swallow, and Blackpoll Warbler. The second largest group (30%) are birds of the Beringian element and include such species as the Yellow-billed Loon, Emperor Goose, Surfbird, and Aleutian Tern. The remaining species are derived from the Panboreal (15%), Old World (6%), and South American (2%) elements.

The last introductory chapter briefly discusses the seasonal (actually monthly) patterns of avian activities on the Peninsula which makes good reading. It will be most useful to birdwatchers planning trips to the area. I was surprised to learn that the Dipper, Northern Shrike, and White-winged Crossbill were some of 26 species that overwinter on the Peninsula.

The strength of this book lies in the annotated list of 215 species which takes up about 65% of the total pages. Species accounts vary from barely three lines (Eurasian Wryneck) to nearly four pages (Oldsquaw) depending on the amount of information available. Complete accounts include information on status, abundance, migration phenology, breeding chronology, habitat requirements, incubation and fledging periods, populations, foods, behaviour, nesting densities, clutch and brood size, and predation. Occasionally the significance of birds on the Seward Peninsula is put in perspective to other areas of Alaska and North America. Each account is well referenced to literature. In fact, the Literature Cited section of the book includes 513 references and occupies 37 pages.

Generally the text is stiff and at times difficult to read, not because of poor writing, but rather to the excessive use of citations and some scientific words.

For example, on one paragraph of eight lines nearly three are taken up by references alone some of which I felt were repetitive. And most readers would not understand words like "stenophilic", "arvicolar", "polynyas", "graminoid", and "euryphilic". Ten delightful line drawings are scattered throughout the book. More would have taken the edge off an otherwise technical text.

Editing has been superb. There are very few typographical errors and other mistakes. One that should be noted, however, is the incorrect spelling of Fraser River (e.g. Frazer River) in British Columbia. A minor inconsistency is the reference to "Bird Species List" in the contents and "Bird Species Index" on page 321. Also I found it mildly irritating to have two separate indexes. A common index, incorporating general references with common and scientific names of species, would have been preferable.

This book is the definitive work on birds of the Seward Peninsula. It is an excellent reference which will have to be in the libraries of ornithologists, wildlife managers, environmental consultants and serious birdwatchers, especially in the Pacific Northwest.

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Whales, Dolphins and Porpoises

Edited by Richard Harrison and Michael Bryden. 1988. Facts on File, New York. 240 pp., illus. U.S. $35.00.

Books on cetaceans have appeared with increasing frequency in recent years, as publishers attempt to match our fascination with these remarkable aquatic mammals. It is with more than passing scepticism, therefore, that I pick up new volumes to see how they attempt to fit into what has become a rather crowded genre. This book attempts to find a niche by acting as a generalist rather than a specialist and, like most generalists, the book succeeds in some aspects and fails in others. The main strength of the book is its combination of superb photography and informative text.

The book is comprised of sixteen chapters, written by fourteen contributors, mostly well-known researchers from the U.K. or South Pacific. The chapters are organized into three sections: Whales of the World, The World of the Whale, and Whales and People. The multi-author format brings a welcome diversity of backgrounds and opinions, but also leaves a rather fragmented impression, with little sense of continuity to tie the chapters together. A stronger editorial hand might have alleviated this problem and also eliminated some repetitive material.

This large format book is worth owning for the photography alone, although perhaps the quality of the photographs can be truly appreciated only by readers who have attempted to capture these animals with a camera. After leafing through the book, I reflected glumly on my photographic collection of out-of-focus dolphins and patches of water where porpoises had just submerged.

Although the book will provide a useful reference on the basic biology of cetaceans for field naturalists it does not contain much information that can be used in the field, despite the inclusion of a chapter on Kinds of Whales by Lawrence Barnes and Carson Creagh. The illustrations in this chapter are disappointing and, in many cases, the proportions of animals are simply wrong. Naturalists interested in a field guide to cetaceans should consult the excellent handbook produced by Leatherwood and Reeves (1983).

I found few typographical or factual mistakes in the book, although some speculative information is occasionally presented with more certainty than is warranted. An example of this latter tendency is Margaret Klinowska's chapter on Strandings - Fact and Fiction, in which she describes her intriguing hypothesis that live strandings are caused by navigational errors made by individuals relying on geomagnetic cues. Unfortunately we don't yet know whether or not cetaceans can detect slight differences in the geomagnetic field, so Klinowska's idea should be considered as one of several plausible hypotheses that may explain this mysterious phenomenon.

I have a more serious objection to the chapter on Whales and Dolphins in Captivity by Victor Manton. Presumably written in response to campaigns intended to restrict or eliminate the practice of keeping cetaceans in captivity, Manton has chosen to present only the benefits of captivity without a serious discussion of the opposing viewpoint. Readers should be aware that many of the supposed benefits of captivity, particularly public education, are being seriously questioned by some researchers.

Literature Cited

Leatherwood, S., and **R.Reeves.** 1983. The Sierra Club Handbook of Whales and Dolphins. Sierra Club Books, San Franscico. 302 pages.

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A Guide to the Birds of Puerto Rico and the Virgin Islands

By Herbert A. Raffaele. 1989. Revised edition. Princeton University Press, Princeton. x + 254 pp. + plates. Cloth U.S. $39.50; paper U.S. $15.95.

The first edition of this guide appeared in 1983 just on time for me to "field test" during the field trips and spare moments of an ornithological conference on Puerto Rico. The birdwatchers among the scientists present found it a useful and generally reliable guide, and I have since found it a valuable supplement to James Bond's guide to the birds of the West Indies while helping to train banders in Cuba. This second edition is an expanded and updated version of the first.

The text begins with a series of introductory sections that include not only the usual definitions and guides to using the book, but also interesting accounts of the biogeography of the islands and conservation problems confronted by biologists there, along with attempts to address and correct them. An unnumbered plate illustrating the "descriptive parts" of a bird precedes 41 plates (all but 17 in colour) of most birds that have occurred on at least one of the islands. Most of the plates are identical to those of the first edition except that the names of the birds have been updated, but two (pigeons and doves, and fall warblers) have been redone and one on accidentals has been added. The bulk of the text consists of species accounts, each composed of sections on identification, local names (including Spanish ones), "comments" (local distribution, status, habitat, etc.), voice, and (overall) distribution. An additional section on clutch size, egg descriptions, and nests is added for each species that breeds on the islands. Each family also receives a brief (usually a paragraph) introduction. These accounts are followed by an annotated list of vagrants, unestablished exotics, and published hypothetical records. The book is concluded with seven site guides, a checklist by locality, an index, and maps of the islands.

The book is generally of high quality, with a well-written text free of many grammatical and proof-reading errors, most notably a missing "r" from tanager on the caption facing plate 38 and "Boneparte's" for Bonaparte's Gull on page 199. The text and plates are cross-referenced accurately. Identification pointers include behavioural and habitat features, although a few could have been added, such as the frequent rocking motion in the flight of Turkey Vultures and the fact that Palm Warblers spend most of their time in the open on the ground. A few accounts are of little help, such as the statement that differentiating cormorants should be left to experts, with no indication of what those experts might look for. Some features mentioned in the captions of plates are not repeated in the text (such as blue primaries of two parrot species and the back colour of Adelaide's Warbler), and some features useful in separating two species (such as the "capped" look of Cooper's Hawk and relative bill length in comparison with head length of the two yellowlegs) are mentioned under one species, but not the other. I had a few other minor quibbles with identification points, but on the whole, found the text accurate and up to date.

The plates, mostly by Cindy J. House and John Wiessinger, range from lovely portraits of some of the endemics that seem to capture the essence of the species well to rather grotesque drawings that appear to have been based on poorly prepared specimens. Most of the latter, however, show the features useful for identification well, and thus serve their purpose. I have seen Tree Swallows as green as that portrayed, but most North Americans will be more familiar with much bluer birds. The legs of Arctic Terns are shorter than shown in most drawings of this species, but are still too long.

In short, I recommend this guide highly to birdwatchers visiting not only Puerto Rico or the Virgin Islands, but also elsewhere in the Caribbean. I hope it will also be published in Spanish.

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BOTANY

Weeds and Words: The Etymology of the Scientific Names of Weeds and Crops

By Robert L. Zimdahl. 1989. Iowa State University Press, Ames, Iowa. xix + 125 pp., illus. U.S. $19.95 + U.S. $2.00 postage.

Why would anyone want to read a book that simply lists 228 weed species and 35 crop species by their Latin names, explains the meaning of each name and its derivation, comments on the appropriateness of the name, and provides a few details about the plant? The author, Dr. Robert Zimdahl of Colorado State University, states that his aim in writing this book was to "help students and others to overcome their difficulties with

scientific names and to familiarize them with their origin." Zimdahl found that students expressed greater interest in a Latin name and were more likely to remember it if they knew the history and understood the meaning of that name.

The book begins with ten pages of Preface and Introduction that are well worth reading. First, the author explains that Latin is used because it is a dead language; thus it is not evolving, the rules are fixed, and daily use will not lead to new and different forms and/or meanings of words. Reference is made to Linnaeus and to the binomial (two word) system of nomenclature. An explanation of the need for an authority for each name is also given.

One-hundred and twenty-one of the species mentioned are also listed in *Common and Botanical Names of Weeds in Canada* by J.F. Alex, R. Cayouette and G.A. Mulligan. Several other species are close relatives of Canadian weeds. Canadian readers may be most surprised by the many differences in common names between the United States and Canada. Some differences are minor; prickly-pear (Canada) vs. pricklypear (U.S.A.), curled dock vs. curly dock, field pepper-grass vs. field pepperweed. However, did you know that our Canada fleabane is called horseweed in the U.S.A., stork's-bill is redstar filaree, nodding thistle is musk thistle, flower-of-an-hour is Venice mallow, and meadow goat's beard is meadow salsify?

The heart of the book, of course, is the information about Latin names. Two examples illustrate that such information may well describe the characteristics of the plant. 1. *Urtica dioica* L., stinging nettle; *Urtica* is the Latin name for nettle; *uro* is the Latin verb to burn or to sting; *urticare* is another Latin verb meaning to sting. The specific name comes from the Greek *di* — two, and *oikos* — house. It refers to the dioecious nature of this species with female flowers on one plant and male flowers on another (i.e. the flowers have two homes). 2. *Verbascum thapsus* L., common mullein: *Verbascum* is a name given by Pliny. It is probably a corruption of the Latin *Barbascum*, which meant a hairy plant and came from the Latin *barba*, or beard. *V. thapsus* could have originated in Thapsos, Sicily, or Thapsus, Tunisia, as both are logical and fit the specific name.

In contrast, some names are remarkably inappropriate. *Ambrosia artemisiifolia* L., common ragweed: *Ambrosia* is Greek for immortality; food for the Gods. *Artemis* is Greek for Diana, sister of Apollo, and a virgin huntress. *Folia* is Latin, plural of *folium*, and refers to many layers of leaves. Certainly the generic name will seem a joke to hay fever sufferers. Unlike several other authors, Zimdahl does not suggest that the specific name refers to the similarity of ragweed leaves and those of *Artemisia* species.

Many Latin names of crops are less exciting. For example, *Avena sativa* is from *avena*, Latin for oats, and *satus*, Latin for a planting or *sativus*, Latin for sown or planted. Zimdahl has also included some, however, that are intriguing, confusing or just wrong.

For example, Zimdahl lists *Brassica kaber* and *Sinapis arvensis* as different species, whereas all five local floras that I consulted (including Common and Botanical Names of Weeds in Canada) list them as synonyms for the same species, wild mustard. Other names are out of date; e.g. *Conyza canadensis* has been revised to *Erigeron canadensis*, *Lynchnis alba* has gone through several revisions and is now *Silene pratensis*. There are other taxonomic errors. Zimdahl states that "*Panicum miliaceum*, proso millet, is an annual and a close relative of cultivated millet, which bears the same scientific name. It escaped to become a weed in many central U.S. states. . . .This may be an example of a plant where continued taxonomic investigation will result in further refinement of identification and it may well become a separate species." In fact, recent taxonomic investigation, published before this book and summarized by Dr. S. Warwick of Ottawa at the 1989 Weed Science Society of America meetings, revealed that weed and crop biotypes are closely related and cannot be separated taxonomically. Also, the weediest biotype of proso millet (black-seeded) is almost certainly a recent introduction from Europe or Asia. It is not an escaped crop.

The book, as a whole, is quite prosaic. Weeds with somewhat improper names are omitted. An example is Scotch thistle, whose Latin generic name, *Onopordum*, comes from the Greek words *onos*, a donkey, and *porde,* flatulence. Obviously, donkeys that eat Scotch thistle are not in good odour!

In summary, it is unlikely that you will rush out to purchase this book. Nevertheless, you may wish to consult it at your local public or specialized library, especially if you have an interest in Latin names.

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Intermountain Flora, Vascular Plants of the Intermountain West, U.S.A. Volume 3B, Fabales

By R. C. Barneby *in* A. Cronquist, A. H. Holmgren, N. H. Holmgren, J. L. Reveal, and P. K. Holmgren. 1989. The New York Botanical Garden, Bronx. 279 pp., illus. U.S. $61.85 in U.S.A.; U.S. $63.20 elsewhere.

This is the fourth volume of six that were proposed for the Intermountain Flora, but now it would appear that three are still to come. Those previously published are Volume 1, Ferns and Fern Allies (with introductory materials) (1972), Volume 6, Monocotyledonae (1977) and Volume 4, subclass Asteridae (except Asteraceae) (1984). All have been reviewed in previous issues of *The Canadian Field-Naturalist*.

The present volume dealing with the Fabales, treats the families Mimosaceae, Caesalpiniaceae and Fabaceae. With the exception of two genera, *Pediomelum* and *Psoralidium* which were authored by James W. Grimes, the work was done by Rupert C. Barneby. For this group in North America no better author could have been chosen. Like the other volumes, excellent keys, extremely detailed descriptions, synonymy with bibliographic references, and information on types, habitat, and distributional (both overall and within the Intermountain) information are provided. These are followed in many cases by most interesting and useful comments, and where needed, the suggestion that further investigation of a particular entity or group should be undertaken. Many of the excellent line drawings by Jeanne R. Janish which were first published in *Vascular Plants of the Pacific Northwest* are reproduced in this volume together with equally well-executed new drawings by Bobbi Angell.

Like the earlier volumes, chromosome numbers are given, but again, unfortunately, there is no indication as to whether or not the counts were based on Intermountain material.

In this volume, seven new taxa have been described and twenty transfers have been made. A list of these Nomenclatural Innovations is provided on page 268.

A welcome innovation on the inside front and back covers and facing pages are maps depicting the location of the Intermountain Region in North America, the states and counties covered by the flora, and the Floristic Divisions and Sections of the Intermountain Region.

It is now nineteen years since the first volume of Intermountain Flora was published. One hopes that the remaining volumes will appear in the near future.

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Eastern North America as seen by a Botanist: Pictorial I, The Arctic Region; and Pictorial II, The Wooded Regions

By In-Cho Chung. 1989. Available from the author, 1308 Laurel Drive, Daytona Beach, Florida 32017. I. pp. 1-112, illus. U.S. $32.00; II. pp. 213-419, illus. U.S. $73.00. (2 volume set U.S. $89.00).

These two volumes, like the author's earlier book *The Arctic and the Rockies as seen by a Botanist: Pictorial* (1985), contain a collection of absolutely beautiful photographs of plants and habitats that few of us will ever have the opportunity to see to any extent in the wild. In-Cho Chung has travelled widely across North America and to its northernmost parts, and with his camera has brought back these wonderful records. He is to be congratulated most heartily.

Volume I of this pair, entitled *The Arctic Region* depicts some 286 habitats and close-ups of plants in bright colour. These illustrations are accompanied by short paragraphs indicating the location where the picture was taken, some brief descriptive notes, the habitat, and range.

Volume II, *The Wooded Regions* takes the reader from the subarctic Canadian Shield via 852 photographs through the Canadian and United States Appalachians to the Coastal Plain. This is followed by a section entitled "Common Mushrooms of the Temperate Regions".

Both volumes include "Selected References" and an Index. Volume I has a short introduction plus acknowledgements and a short Appendix concerning plants common to the northernmost parts of Ellesmere Island and Greenland north of the 81st parallel.

If you are looking for a gift for some friend who has a love of plants, go no further!!

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The Genus *Vaccinium* in North America

By S. P. Vander Kloet. 1988. Agriculture Canada Research Branch Publication 1828. Canadian Government Publishing Centre, Ottawa. xi + 201 pp., illus $48.50.

Blueberries amd cranberries are familiar to most North Americans, at least in a general way. Many of us enjoy eating them, either in pies and pastries, or freshly harvested from wild plants. However, to those who have collected these plants and tried to puzzle out their species limits, the blueberries in particular have probably been perplexing. I have had personal experience (and frustration) with several of the eastern and western species complexes. The number of opinions on species limits is almost equal to the number of floristic and taxonomic treatments that have been written about them.

This monograph provides a synthesis of the taxonomically relevant information on ecology, morphology, cytology, and reproductive biology of the blueberries and cranberries. But it also does much more than that. A large introductory section provides a good review of many areas of *Vaccinium* utilization and biology, including cultivation, growth and development, pollination, dispersal, habitats, mycorrhizal associations, cytology, and hybridization. One of the nice features of this book is that it provides much of the basic information that goes into a taxonomic treatment; information that is often omitted in the more terse format of the technical journals. More importantly, this information is presented in an interesting, readable, almost chatty style that makes the whole book accessible to both amateur and professional botanists. By writing in this style, I think Sam Vander Kloet will succeed in helping all readers to understand how taxonomic work is done, or at least, how many sources of data are considered in arriving at a classification scheme for a group of related species.

Since there are so many different opinions on what constitutes a species in *Vaccinium*, it is important in any treatment of this genus that the author provides a well defined species concept. In this book, the author has done so in a very clear and concise way. Thus, although some people might disagree with his species concept, there can be no question about his reasoning and methodology.

There are both vegetative keys and keys to flowering/fruiting material included. The vegetative keys are broken down by region, so that Arctic species can be keyed without having to contend with the western North American species, for example. Five regions are defined using a map to avoid any problems of interpretation. All 26 species included in this monograph are described, illustrated, mapped, and discussed in terms of habitat and economic importance.

As with all classification schemes, there are still unsolved taxonomic and evolutionary problems, and the author has identified and highlighted many of these in the introductory sections and elsewhere in the text. Several questions came to mind as I read the book, and I am sure that others will occur to other readers; these are all areas worthy of future study. For example, a hybrid origin has been suggested for the highbush blueberry, *V. corymbosum* L., but the appropriate experiments to test this idea have not yet been conducted. Also, beyond the general grouping of similar species within sections, the evolutionary relationships of the species are not well known. Cladistic analyses will provide one means of determining these relationships with more precision (I believe such analyses are underway but the results were not ready for inclusion in this book). From the perspective of floral biology, I am curious about the function of the awns on the anthers of certain species. One can speculate on such things, but experimental evidence is preferable.

I detected a small number of typographical and other errors in the text, but all in all, the writing style, content, layout, and graphics are excellent. The legend for Figure 5 (p. 17) lists *V. caespitosum* Michx. for both parts 'H' and 'I', but I think 'H' should be *V. stamineum* L. On p. 147, the authority for *V. parvifolium* should be Smith, not Small. The illustrations of *V. macrocarpon* Ait. and *V. oxycoccus* L. (the cranberries) could have been improved by indicating the bracts on the pedicels (which differ in size and position between species) more clearly.

My impression of this book is very favorable. I recommend it to anyone interested in the classification, distribution, ecology, economic use, or ethnobotany of the North American blueberries and cranberries.

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ENVIRONMENT

Toward a Common Future: A Report on Sustainable Development and its Implications for Canada

By Michael Keating. 1989. Environment Canada. Ministry of Supply and Services Canada, Ottawa. iv + 48 pp., illus. Free.

You've probably seen those events at rural agricultural fairs where they take a young pig, grease it up with lard or petroleum jelly, and turn it loose in a muddy pen for kids to catch. The object of this dubious entertainment is for the pursuer to capture the hapless swine with his bare hands in the shortest possible time. The contestant who subdues the indignant porker the most rapidly is the winner of the event (the pig inevitably loses). Though barbaric and unsophisticated, the contest is not without its considerable challenges . . . a greased pig is a slippery beast to deal with, and the pursuers must negotiate muddy holes and slimy surfaces at high speed until they corner the beast. Grabbing on to hocks, tail, neck, waist, or ears, the participants must then endure the full fury of righteous porcine indignation until the judges deem that the pig has been well and truly captured. It's a dirty, messy, difficult business.

These events are (mercifully) less frequent these days than in decades past, due in part to the judicious outrage of swine lovers everywhere. But I'm reminded of them every time I encounter someone trying to define and discuss that ubiquitous environmental buzzterm, "sustainable development". Like a greased pig, "sustainable development" is a slippery concept to grab hold of, and one's interpretation of the weight, bulk, and tractability of the beast varies significantly depending upon which of its metaphorical appendages the pursuer grabs hold of. Everyone, from deep ecologist to corporate tycoon, seems to have something to say about this peculiar oxymoron. The emphasis switches alarmingly from "sustainable" to "development" depending upon the stripe of the individual pursuer, and upon which particular corner of the ideological pigpen is being negotiated. Those pursuers who attempt to reconcile all the different perspectives must risk falling into a number of interpretive potholes and emerging very muddy indeed, but their exertions are necessary if we are to determine the usefulness (or uselessness) of the concept. Semantic wrangling aside, it's generally easier (and often more useful) to identify what sustainable development *isn't*. I was curious as to how soiled author Michael Keating would get in *Toward a Common Future: A report on sustainable development and its implications for Canada*.

The 48-page Environment Canada document is essentially a primer of environmental issues based upon the 1987 recommendations of the World Commission on Environment and Development (the Bruntland Commission). The first section of the report, "The Way We Are", delineates current and future environmental problems (greenhouse effect, stratospheric ozone depletion, acid deposition, nuclear winter, land use issues, water use and pollution, marine resources and pollution, chemical effluents, solid waste, and reduction of biological diversity). Treatment of each of these issues is of course cursory; one can hardly expect detailed analysis of all the environmental woes of the world in 20 pages. However, the overview seems clear, readable, factually accurate (though unreferenced), and provides a Canadian perspective on these problems.

The second section of the report, "Beyond Panic", is subtitled "The new environment-economy agenda of sustainable development". Keating has avoided much of the potential ideological mire by remaining very middle-of-the-road. The closest he comes to a formal definition of sustainable development is by quoting the National Task Force on Environment and Economy in *their* paraphrase of the Bruntland report's definition: "development which ensures that the utilization of resources and the environment today does not damage prospects for their use by future generations." He later acknowledges that we have yet to develop a clear picture of how to "do business sustainably", and illustrates only the "obvious pathways" that Canadians should follow in their pursuit of this elusive goal: reducing per capita energy and resource consumption, reducing waste discharges and wastage of natural resources, and broadening our notions of development to include resource accounting and the internalization of externalities. Nonetheless, it provides a useful summary of Canadian and international initiatives aimed at saving the atmosphere, land, and waters, making energy sustainable, improving waste management, and saving wildlands and wildlife.

Unfortunately, this report suffers from the same syndrome as do many others of its ilke: it speaks in broad generalities about environmental problems most educated Canadians are already aware of, and proposes many "solutions" which are noble and necessary without providing insight into how they might be implemented. We all know, for example, that "governments can modify policies to pass laws forbidding virtually all release of persistently harmful chemicals", or that "businesses should develop a broad environmental ethic and code of practice". . . but *how?* Existing or proposed Canadian initiatives to deal with a variety of

environmental problems are summarized in the final pages of the report, but they are taken at face value. There is little in the way of practical advice or policy analysis here.

As Timothy O'Riordan stated in *The Politics of Sustainability*, the "beguiling simplicity" of the term "sustainability" will cause it to become so abused as to become meaningless; it is "probably going to languish as a 'good idea' which cannot sensibly be put into practice — like 'democracy' and 'accountability' ". It appears that O'Riordan's fears are not unfounded; *Toward A Common Future* features quotes in this context by such environmental luminaries as Brian Mulroney, Margaret Thatcher, Michael Wilson, and the World Bank's Barber Conable. The uncritical description of Canadian governmental and industrial initiatives may accentuate the positive in an area where good news is depressingly scarce, but the author's benign acceptance of the political status quo and failure to explore some of the complexities of sustainable development leads one to suspect that this document was designed to *reassure* as much as it was to inform. It's a good general overview of current environmental issues, and it's free. But author Keating would have benefited greatly by getting a little bit of metaphorical mud on his boots, instead of simply observing the swine from the top of the fence.

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MISCELLANEOUS

Lewis & Clark: Pioneering Naturalists

By Paul Russel Cutright. 1989. University of Nebraska Press, Lincoln. xiii + 506 pp., illus. Paper. U.S. $14.95.

To many naturalists Clark's Nutcracker and Lewis' Woodpecker are the only reminders of the early 19th century expedition across the newly acquired Louisiana Territory to the Western Ocean. Yet the legacy of Captains Merriwether Lewis and William Clark goes far beyond the discovery of two birds. The two men were sent on an overland expedition by President Thomas Jefferson of the United States to discover and map the geographic features, and study the ethnography, flora, and fauna of the mysterious hinterland of the young American republic.

The author traces the historical background of the expedition through the Louisiana purchase of 1803. He discusses Jefferson's interest in natural history and his "blueprint for discovery" and follows the slow progress of Lewis and Clark and their hand-picked group of men from their first winter quarters at Wood River, Illinois, along the Missouri River to Yellowstone, and across the mountain barrier to the "Western Ocean", and back to St. Louis. Cutright skillfully weaves the various strands of the narrative: excerpts from the diaries and letters of the two leaders and some of their men, information from later explorers, and from numerous Lewis and Clark scholars, and his own observations and interpretation of the events of this historic expedition. His vivid descriptions are based on a thorough knowledge of the Lewis and Clark saga, familiarity with the diverse source material, a first hand acquaintance with most of the route, and knowledge of the plants and animals encountered during the arduous 1804-1806 trip by the pioneering naturalists.

Nineteen of the 23 chapters concerning particular segments of the expedition have summaries of the discoveries discussed in those chapters. These include animals and plants new to science, specimens in the Lewis and Clark Herbarium, "Indian Tribes Encountered," and "Topographic features named/and or discovered." Additionally, at the end of the book Appendix A and B provide total lists of the plants and animals discovered by the explorers (some of which are shown on black-and-white plates in the book), and Appendix C consists of the "Locations of Lewis and Clark Journals, Maps, and Related Materials." There is also a detailed bibliography and an index.

It is unfortunate that this well researched and written book (first published in 1969) contains no map of the route of the expedition. The reader will have to juggle the book plus a detailed map or atlas to be able to locate the events described in the various chapters, a cumbersome, annoying and unnecessary task. With this in mind, I would nevertheless recommend this fascinating volume to all practicing and aspiring naturalists.

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Himalayas

By Blanche Olschak, Augusto Gansser, Andreas Gruschke, and Emil Buhrer. Facts on File Books, New York. 288 pp., illus. U.S. $40.00, $55.00 in Canada.

This book is one of the best overviews and introductions to the Himalayas I have seen. Illustrated with outstanding photos of native people, scenery, geology, and cultural sites, the photos alone make this book worth its U.S. $40.00 price tag. However, there are also good topographic maps, satellite photos, a geological map, and a variety of diagrams that assist the reader in understanding the complex geology and geography of this region. Finally, there is an appendix which includes a portrait of each Himalayan country giving a brief description of its history, people, language, religion, and economy.

Though one could spend hours looking over the photos, the main body of the text is marvellous reading with a mix of history, cultural observations, as well as natural history descriptions, which attempts to put into perspective the great diversity of landscapes, cultures, and people found in the Himalayan region.

One of the authors, Dr. Augusto Gansser was one of the first geologists to explore the Himalayan region. During his early expeditions, touching stones, much less examining them, was sacreligious. As a consequence, Gansser disguised himself as a monk and hidden inside his robes were sketchbooks, rock hammer, and other tools of his trade. Travelling as a pilgrim, he explored and described the geology to some previously unknown regions. His descriptions of his early travels of this mountain region prior to World War II read more like an adventure story than a text.

Another of the authors, Dr. Blanche Olschak specializes in prehistory of Central Asia and Buddhism. She adds much to the cultural descriptions in the book which includes discussions of Himalayan religion, buildings and temples.

None of the authors are biologists, hence the only short-coming of the book is the limited review of native flora and fauna. Though one might want to know more about the natural history, there is plenty of information contained in this book for anyone to digest.

GEORGE WUERTHNER

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NEW TITLES

Zoology

Bird life of mountain and upland. 1990. By Derek Ratcliffe. Cambridge University Press, New York. c280 pp., illus. cU.S.$39.50.

Bird migration. 1990. By Thomas Alerstam. Translated by David A. Christie. Cambridge University Press, New York. c400 pp., illus. cU.S.$105.

Birds of the high Andes. 1990. By Jon Fjeldsa and Niels Krabbe. Apollo Books, Svendborg, Denmark. 880 pp., illus. DKK 700 + postage.

***Food hoarding in animals.** 1990. By Stephan B. Vander Wall. University of Chicago Press, Chicago. xi + 445 pp., illus. Cloth U.S.$76; paper U.S.$29.95.

***Freshwater macroinvertebrates of northeastern North America.** 1990. By Barbara L. Peckarsky, Pierre R. Fraissinet, Marjory A. Peton, and Don J. Conklin, Jr. Comstock (Cornell University Press, Ithaca). 442 pp., illus. Cloth U.S.$57.50, paper U.S.$26.50.

†**Golden-crowned kinglets: treetop nesters of the north woods.** 1990. By Robert Galati. Iowa State University Press, Ames. 160 pp., illus. cU.S.$16.95.

***The natural history of moles.** 1990. By Martyn L. Gorman and R. David Stone. Cornell University Press, Ithaca. xiv + 138 pp., illus. U.S.$27.50

Inglewood Bird Sanctuary: a place for all seasons. 1990. By Dave Elpinstone. Rocky Mountain Books, Calgary. 128 pp., illus. $4.95.

***Invertebrates.** 1990. By Richard C. and Gary J. Brusca. Sinauer Associates, Sunderland, Massachusetts. 922 pp., illus. U.S.$47.50.

†**The Jackson elk herd: intensive wildlife management in North America.** 1990. By Mark S. Boyce. Cambridge University Press, New York. xiii + 306 pp., illus. U.S.$75.

***Life history and ecology of the slider turtle.** 1990. By J. Whitfield Gibbons. Smithsonian Institute Press, Washington. xiv + 368 pp., illus. U.S.$60.

†**Owls, caves, and fossils: predation, preservation, and accumulation of small mammal bones in caves, with an analysis of pleistocene cave faunas from Westbury-sub-Mendip, Somerset.** 1990. By Peter Andrews. University of Chicago Press, Chicago. c390 pp., illus. cU.S.$39.95.

†**Protecting internationally important bird sites: a review of the EEC special protection area network in Great Britain.** 1990. By David A. Stroud, G. P. Mudge, and M. W. Pienkowski. Nature Conservancy Council, Peterborough, Great Britain. 230 pp., illus. £17.

Ravens in winter. 1989. By Bernd Heinrich. Summit (Simon and Schuster, New York). 379 pp., illus. U.S.$19.95.

†**Studying animal behavior: autobiographies of the founders.** 1989. Edited by Donald A. Dewsbury. University of Chicago Press, Chicago. 512 pp., illus. U.S.$19.95.

Botany

The biology of *Frankia* and actinorhizal plants. 1990. Edited by Crista R. Schwintzer and John D. Tjepkema. Academic Press (Harcourt Brace Jovanovich, San Diego). 408 pp., U.S.$95.

†**A checklist of the flora of Ontario vascular plants.** 1990. By J. K. Morton and Joan M. Venn. Biology Series No. 34. University of Waterloo, Waterloo. x + 218 pp.

*__Discovering wild plants: Alaska, western Canada, the northwest.__ 1990. By Janice Schofield. Alaska Northwest (GTE Discovery, Bothell, Washington). 368 pp., illus. Cloth U.S.$34.95; paper U.S.$24.95; Canadian $43.95 and $29.95 respectively.

Environmental injury to plants. 1990. Edited by Frank Katterman. Academic Press, New York. c280 pp. U.S.$50.

†**Field guide to the peat mosses of boreal North America.** 1990. By Cyrus B. McQueen. University of New England Press, Hanover, New Hampshire. xiv + 138 pp., illus. + plates.

Morphology, development, and systematic relevance of pollen and spores. 1990. Edited by M. Hesse and F. Ehrendorfer. Supplementum 5, Plant Systematics and Evolution. Springer-Verlag, Wien. vii + 124 pp., illus. DM 138; OS 980.

†**Nature's heartland: native plant communities of the Great Plains, illustrated in seasonal color.** 1990. By Bill Boon and Harlen Groe. Iowa State University Press, Ames. 368 pp., illus. cU.S.$39.95.

Perspectives on plant competition. 1990. Edited by James B. Grace and David Tilman. Academic Press, (Harcourt Brace Jovanovich, San Diego). 484 pp., U.S.$79.95.

Research advances in the Cosmpositae. 1990. Edited by T J. Mabry and G. Wagenitz. Supplementum 4, Plant Systematics and Evolution. Springer-Verlag, Wien. v + 124 pp., illus. DM 138; OS 980.

A reunion of trees: the discovery of exotic plants and their introduction into North American and European landscapes. 1990. By Stephen A. Spongberg. Harvard University Press, Cambridge, Massachusetts. 352 pp., illus. U.S.$35.

Wild plants of America: a select guide for the naturalist and traveller. 1989. By Richard M. Smith. Wiley, New York. xix + 267 pp. Cloth U.S.$22.95; paper U.S.$12.95.

Woody plants — evolution and distribution since the Tertiary. 1989. Edited by F. Ehrendorfer. Proceedings of a symposium, 9-11 October, 1986, Halle/Saale, German Democratic Republic. Plant Systematics and Evolution, Volume 162. Springer-Verlag, Wien. v + 329 pp., illus. DM 310: OS 2170.

Environment

Air toxics and risk assessment. 1990. By Edward J. Calabrese and Elaina Kenyon. Lewis, Boca Raton, Florida. 480 pp. cU.S.$75 in U.S.A.; U.S.$89 elsewhere.

†**The Cambridge illustrated dictionary of natural history.** 1987, 1990. By R. J. Lincoln and G. A. Boxshall. Cambridge University Press, New York. 413 pp., illus. Paperback edition.

Controlling pollution from Canadian pulp and paper manufacturers: a federal perspective. 1990. By William F. Sinclair. Canadian Government Publishing Centre, Ottawa. $36.95 in Canada; U.S.$44.35 elsewhere.

†**Dynamic biogeography.** 1990. By R. Hengeveld. Cambridge University Press, New York. xiv +249 pp., illus. U.S.$54.50.

The fragile environment: the Darwin College lectures. 1989. Edited by Laurie Friday and Ronald Laskey. Cambridge University Press, New York. x + 198 pp., illus. U.S.$19.95.

Greenhouse warming: abatement and adaptation. 1989. Edited by Norman J. Rosenberg,. et al. Resources for the Future, Washington. xiii + 182 pp., illus. U.S.$18.95.

In situ evaluation of biological hazards of environmental pollutants. 1990. Edited by Shahbeg S. Sandhu, William R. Lowr, Frederick J. de Serres, William A. Suk, and Raymond R. Tice. Proceedings of a symposium, Chapel Hill, North Carolina, 5-7 December, 1988. Plenum, New York. c266 pp. U.S.$65.

Light and life in the sea. 1990. Edited by P. J. Herring, A. K. Campbell, M. Whitfield, and L. Maddock. Cambridge University Press, New York. c350 pp. cU.S.$69.95.

Ozone risk communication and management. 1990. Edited by Edward J. Calabrese and Charles Gilbert. Lewis, Boca Raton, Florida. 250 pp. U.S.$69.95 in U.S.A.; U.S.$82 elsewhere.

Shore ecology of the Gulf of Mexico. 1989. By Joseph C. Britton and Brian Morton. University of Texas Press, Austin. xvvv + 387 pp., illus. Cloth U.S.$49.95; paper U.S.$22.50.

Sustaining the earth. 1990. By John Young. Harvard University Press, Cambridge, Massachusetts. 200 pp. U.S.$19.95.

Miscellaneous

†**Canada's missing dimension: science and history in the Canadian Arctic islands.** 1990. Edited by C. R. Harington. National Museum of Natural Sciences, Ottawa. 2 volume set, 855 pp., illus. $25.

†**Causes of evolution: a paleontological perspective.** 1990. By Robert M. Ross and Warren D. Allmon. University of Chicago Press, Chicago. c368 pp., illus. Cloth cU.S.$50; paper cU.S.$19.95.

†**Evolutionary innovations.** 1990. By Matthew H. Nitecki. University of Chicago Press, Chicago. c330 pp., illus. Cloth U.S.$44.95; paper cU.S.$17.95.

Rainforest: a guide to research and tourist facilities at selected tropical forest sites in Central and South America.1990. Feline Press, Gainesville, Florida. 400 pp., illus. U.S.$21.95.

Speciation and its consequences. 1989. Edited by Daniel Otte and John A. Endler. Sinauer, Sunderland, Massachusetts. xiii + 679 pp., illus. Cloth U.S.$50; paper U.S.$29.95.

The wisdom of the genes: new pathways in evolution. 1989. by Christopher Wills. Basic, New York. xiv + 321 pp., illus. U.S.$19.95.

Books for Young Naturalists

Amazing spiders. 1989. By Claudia Schnieper. Carolrhoada, Minneapolis. 48 pp., illus. U.S.$12.95.

The amazing things that animals do. 1989. By Susan McGrath. National Geographic Society, Washington. 96 pp., illus. U.S.$9.50.

Animal monsters: fantasies and facts of the animal world. 1989. By David Taylor. Lerner, Minneapolis. 47 pp., illus. U.S.$11.95.

Big friend, little friend: a book about symbiosis. 1989. By Susan Sussman and Robert James. Houghton, Mifflin, Boston. 31 pp., illus. U.S.$13.95.

The book of eagles. 1989. By Helen Roney Sattler. Lothrop, Lee, and Sheppard, New York. 64 pp., illus. U.S.$14.95.

Botany: 49 science fair projects. 1989. By Robert L. Bonnet and G. Daniel Keen. Tab, Blue Ridge Summit, Pennsylvania. xii + 148 pp., illus. Cloth U.S.$16.95; paper U.S.$9.95.

Chameleons. 1989. By Claudia Schnieper. Carolrhoda, Minneapolis. 48 pp., illus. U.S.$12.95.

Cheetah. 1989. By Caroline Arnold. Morrow, New York. 48 pp., illus. U.S.$12.95.

†**Dinosaurs.** 1990. By George E. Lammers. Hyperion Press, Winnipeg. 39 pp., illus. $5.95.

Explore a tropical forest and Animal homes. 1989. By the National Geographic Society, Washington. 12 pp., illus. Each U.S.$19.95 (set).

Hermit crabs. 1989. Sylvia A. Johnson. Lerner, Minneapolis. 48 pp., illus. U.S.$12.95.

***Invertebrates.** 1990. By Barbara Batulla. Hyperion Press, Winnipeg. 39 pp., illus. $5.95.

Plant. 1989. By David Burnie. Knopf, New York. 64 pp., illus. U.S.$12.95.

†**Reptiles and amphibians.** 1990. By Robert E. Wrigley. Hyperion Press, Winnipeg. 39 pp., illus. $5.95.

Seashore. 1989. By Steve Parker. Knopf, New York. 64 pp., illus. U.S.$12.95.

Strawberry. 1989. By Jennifer Coldrey and George Bernard. Silver Burdett, Englewood Cliffs, New Jersey. 25 pp., illus. U.S.$6.95.

When turtles come to town. 1989. By Cary B. Ziter. Watts, New York. 63 pp., illus. U.S.$10.90.

†**Wild edibles.** 1990. By Mary E. Hamilton. Hyperion Press, Winnipeg. 39 pp., illus. $5.95.

*assigned for review
†available for review

Advice to Contributors

For full instructions see *The Canadian Field-Naturalist* 104(2): 346, April-June 1990.

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The Ottawa Field-Naturalists' Club

FOUNDED IN 1879

The objectives of this Club shall be to promote the appreciation, preservation and conservation of Canada's natural heritage; to encourage investigation and publish the results of research in all fields of natural history and to diffuse information on these fields as widely as possible; to support and cooperate with organizations engaged in preserving, maintaining or restoring environments of high quality for living things.

Those wishing to communicate with the Club should address correspondence to: The Ottawa Field-Naturalists' Club, Box 3264, Postal Station C, Ottawa, Canada K1Y 4J5. For information on Club activities telephone (613) 722-3050.

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Back Numbers and Index

Most back numbers of this journal and its predecessors, *Transactions of The Ottawa Field-Naturalists' Club*, 1879-1886, and *The Ottawa Naturalist*, 1887-1919, and *Transactions of The Ottawa Field-Naturalists' Club and The Ottawa Naturalist — Index* compiled by John M. Gillett, may be purchased from the Business Manager.

Cover: Ring-billed Gull, *Larus delawarensis*, in flight, Georgian Bay between Southbaymouth and Tobermory, Ontario, June 1988. Photograph courtesy of Chris G. Bloome. See note on feeding in flight on forest tent caterpillar cocoons: pages 280-281

The Canadian Field-Naturalist

Volume 105, Number 2 April–June 1991

Rare and Endangered Fishes and Marine Mammals of Canada: COSEWIC Fish and Marine Mammal Subcommittee Status Reports: VII.

R. R. CAMPBELL

Department of Fisheries and Oceans, 200 Kent Street, Ottawa, Ontario K1A 0E6

Campbell, R. R. *Editor*. 1991. Rare and endangered fish and marine mammals of Canada: COSEWIC Fish and Marine Mammal Subcommittee Status Reports: VII. Canadian Field-Naturalist 105(2): 151–156.

Twelve status reports representing those species of fish and marine mammals which were assigned status at the 1990 COSEWIC General Meeting have been prepared for publication. Committee and Subcommittee (Fish and Marine Mammal) activities are briefly discussed. Current lists of status assignments for fish and marine mammals and for species yet to be considered, or which are under consideration, are presented in tabular form.

Douze rapports de statut représentant les espèces de poissons et de mammifères marins auxquels on a donné un statut à la réunion générale du CSEMDC en 1990 ont été préparés en vue de leur publication. Il y est brièvement question des activités du comité et du sous-comité (poissons et mammifères marins). Les dernières listes de désignation de statut des poissons, des mammifères marins et des espèces qui n'ont pas été considérées, ou dont il faut encore discuter, sont présentées sous forme de tableau.

Key Words: Rare and endangered species, fish, marine mammals, COSEWIC.

As indicated in previous submissions (Campbell 1984, 1985, 1987, 1988, 1989, 1990), the intent of the Subcommittee on Fish and Marine Mammals is to publish the status reports on those species of fish and marine mammals which the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) have reviewed, approved and used as a basis for the assignment of status to species in jeopardy in Canada. The group of 12 reports presented here represent the fish and marine mammal component of those species assigned status in 1990. It is hoped that we will have the continuing support of the Department of Fisheries and Oceans to offer, in succeeding volumes, those reports reviewed in future years (Table 1 presents those species assigned status to April 1990).

Progress

COSEWIC has undertaken to make public, supporting information on each species classified (*see* Cook and Muir 1984). The Fish and Marine Mammal Subcommittee has been able to use this journal as one step in achieving the goal [see *Canadian Field-Naturalist* 98(1): 63-133; 99(3): 404–450; 102(1): 81–176, 102(2): 270–398; 103(2): 147–239; 104(1): 1–145] and the encouraging response to these publications has enabled us to continue.

Contributions to the Committee of $10 000 made by the Department of Fisheries and Oceans and Environment Canada in 1989, once again matched by World Wildlife Fund Canada, permitted the contracting of several new reports in 1989. The Fish and Marine Mammal Subcommittee was able to take advantage of this and 18 reports were initiated in 1989/90. Although there are still a number of reports in preparation or under review (Table 2) the number of species still awaiting consideration has been reduced to 18 (Table 3). It remains the Subcommittee's goal to clear this list by 1992.

There are currently 31 status reports on fish species, and 18 on marine mammal species under review or in preparation (Table 2). Several will be assigned status in 1991. In addition to soliciting further status reports on species of concern, the Subcommittee continues to obtain updates on the status of selected species as new information becomes available.

In addition to the species reported here, the Ungava Bay and eastern Hudson Bay populations of the Beluga Whale (*Delphinapterus leucas*) were re-evaluated (*see* Reeves and Mitchell 1989) and confirmed as endangered and threatened respectively. The Committee also assigned a status of threatened to the western North Atlantic

TABLE 1. Fish and marine mammal species with assigned COSEWIC status to April 1990.

Species	Scientific Name	Status	Date Assigned
Fish			
Lake Sturgeon	*Acipenser fulvescens*	RANSDR[a]	April 1986
Bloater	*Coregonus hoyi*	RANSDR	April 1988
Blueback Herring	*Alosa aestivalis*	RANSDR	April 1980
Hornyhead Chub	*Nocomis biguttatus*	RANSDR	April 1988
River Chub	*Nocomis micropogon*	RANSDR	April 1988
Redfin Shiner	*Notropis umbratilis*	RANSDR	April 1988
Leopard Dace	*Rhinichthys falcatus*	RANSDR	April 1990
Golden Redhorse	*Moxostoma erythrurum*	RANSDR	April 1989
Least Darter	*Etheostoma microperca*	RANSDR	April 1989
River Darter	*Percina shumardi*	RANSDR	April 1989
Green Sunfish	*Lepomis cyanellus*	RANSDR	April 1987
Longear Sunfish	*Lepomis megalotis*	RANSDR	April 1987
Spoonhead Sculpin	*Cottus ricei*	RANSDR	April 1989
Brook Silverside	*Labidesthes sicculus*	RANSDR	April 1989
Darktail Lamprey	*Lethenteron alaskense*	RAISIFSD[b]	April 1990
Bering Cisco	*Coregonus laurettae*	RAISIFSD	April 1990
Lake Lamprey[c]	*Lampetra macrostoma*	Vulnerable[d]	April 1986
Green Sturgeon	*Acipenser medirostris*	Vulnerable	April 1987
Shortnose Sturgeon	*Acipenser brevirostrum*	Vulnerable	April 1980
White Sturgeon	*Acipenser transmontanus*	Vulnerable	April 1990
Spotted Gar	*Lepisosteus oculatus*	Vulnerable	April 1983
Kiyi	*Coregonus kiyi*	Vulnerable	April 1987
Squanga Whitefish[c]	*Coregonus* sp.	Vulnerable	April 1988
Pacific Sardine	*Sardinops sagax*	Vulnerable	April 1987
Silver Chub	*Hybopsis storeriana*	Vulnerable	April 1985
Umatilla Dace	*Rhinichthys umatilla*	Vulnerable	April 1988
Bigmouth Shiner	*Notropis dorsalis*	Vulnerable	April 1985
Pugnose Shiner	*Notropis anogenus*	Vulnerable	April 1985
Silver Shiner	*Notropis photogenis*	Vulnerable	April 1983[e]
Pugnose Minnow	*Notropis emiliae*	Vulnerable	April 1985
Redside Dace	*Clinostomus elongatus*	Vulnerable	April 1987
Speckled Dace	*Rhinichthys osculus*	Vulnerable	April 1980[f]
Central Stoneroller	*Campostoma anomalum*	Vulnerable	April 1985
Banded Killifish (Newfoundland)	*Fundulus diaphanus*	Vulnerable	April 1989
Blackstripe Topminnow	*Fundulus notatus*	Vulnerable	April 1985
Bigmouth Buffalo	*Ictiobus cyprinellus*	Vulnerable	April 1989
Black Buffalo	*Ictiobus niger*	Vulnerable	April 1989
Spotted Sucker	*Minytrema melanops*	Vulnerable	April 1983
River Redhorse	*Moxostoma carinatum*	Vulnerable	April 1983[e]
Greenside Darter	*Etheostoma blennioides*	Vulnerable	April 1990
Brindled Madtom	*Notorus miurus*	Vulnerable	April 1985
Orangespotted Sunfish	*Lepomis humilis*	Vulnerable	April 1989
Redbreast Sunfish	*Lepomis auritus*	Vulnerable	April 1989
Fourhorn Sculpin (Arctic Islands)	*Myoxocephalus quadricornis*	Vulnerable	April 1989
Giant Stickleback[c]	*Gasterosteus* sp.	Vulnerable	April 1980
Unarmoured Stickleback[c]	*Gasterosteus* sp.	Vulnerable	April 1983
Blackline Prickleback	*Acantholumpenus mackayi*	Vulnerable	April 1989
Bering Wolffish	*Anarichus orientalis*	Vulnerable	April 1989
Lake Simcoe Whitefish[c]	*Coregonus clupeaformis* ssp.	Threatened	April 1987
Blackfin Cisco	*Coregonus nigripinnis*	Threatened	April 1988
Shortnose Cisco	*Coregonus reighardi*	Threatened	April 1987
Shortjaw Cisco	*Coregonus zenithicus*	Threatened	April 1987
Deepwater Sculpin (Great Lakes Watershed)	*Myoxocephalus thompsoni*	Threatened	April 1987
Black Redhorse	*Moxostoma dusquesnei*	Threatened	April 1988
Copper Redhorse[c]	*Moxostoma hubbsi*	Threatened	April 1987
Margined Madtom	*Noturus insignis*	Threatened	April 1989
Enos Lake Stickleback[c]	*Gasterosteus* sp.	Threatened	April 1988
Shorthead Sculpin	*Cottus confusus*	Threatened	November 1983
Aurora Trout[c]	*Salvelinus fontinalis timagamiensis*	Endangered	April 1987
Acadian Whitefish[c]	*Coregonus canadensis*	Endangered	April 1983
Salish Sucker	*Catostomus* sp.	Endangered	April 1986
Gravel Chub	*Hybopsis x-punctata*	Extirpated	April 1987[g]
Paddlefish	*Polyodon spathula*	Extirpated	April 1987
Deepwater Cisco	*Coregonus johannae*	Extinct	April 1988
Lonjaw Cisco	*Coregonus alepnae*	Extinct	April 1988

Continued

TABLE 1. *Concluded*

Species	Scientific Name	Status	Date Assigned
Banff Longnose Dace[c]	*Rhinichthys cataractae smithi*	Extinct	April 1987
Blue Walleye	*Stizostedion vitreum glaucum*	Extinct	April 1985
Marine Molluscs			
Northern Abalone	*Haliotis kamtschatkana*	N/A[h]	April 1988
Marine Mammals			
California Sea Lion	*Zalophus californianus*	RANSDR	April 1987
Steller Sea Lion	*Eumetopias jubatus*	RANSDR	April 1987
Atlantic Walrus	*Odobenus rosmarus rosmarus*		
Eastern Arctic		RANSDR	April 1987
Northwest Atlantic		Extirpated	April 1987
Grey Whale	*Eschrichtius robustus*		
Northeast Pacific		RANSDR	April 1987
Northwest Atlantic		Extirpated	April 1987
Hooded Seal	*Cystophora cristata*	RANSDR	April 1986
Northern Elephant Seal	*Mirounga angustirostris*	RANSDR	April 1986
Ringed Seal	*Phoca hispida*	RANSDR	April 1989
Risso's Dolphin	*Grampus griseus*	RANSDR	April 1990
Northern Right Whale Dolphin	*Lissodelphis borealis*	RANSDR	April 1990
Pacific White-sided Dolphin	*Lagenorhynchus obliquidens*	RANSDR	April 1990
Dall's Porpoise	*Phocoenoides dalli*	RANSDR	April 1989
Narwhal	*Monodon monoceros*	RANSDR	April 1986[e]
Blainville's Beaked Whale	*Mesoplodon densirostris*	RANSDR	April 1989
Cuvier's Beaked Whale	*Ziphius cavirostris*	RANSDR	April 1990
Hubbs' Beaked Whale	*Mesoplodon carlhubbsi*	RANSDR	April 1989
Stejneger's Beaked Whale	*Mesoplodon stejnegeri*	RANSDR	April 1989
True's Beaked Whale	*Mesoplodon mirus*	RANSDR	April 1989
False Killer Whale	*Pseudorca crassidens*	RANSDR	April 1990
Beluga	*Delphinapterus leucas*		
Beaufort Sea		RANSDR	April 1986
St. Lawrence River		Endangered	April 1983
Eastern Hudson Bay		Threatened	April 1988
Ungava Bay		Endangered	April 1988
S.E. Baffin Island		Endangered	April 1990
Sowerby's Beaked Whale	*Mesoplodon bidens*	Vulnerable	April 1989
Blue Whale	*Balaenoptera musculus*	Vulnerable	April 1983
Fin Whale	*Balaenoptera physalus*	Vulnerable	April 1987[f]
Sea Otter	*Enhydra lutris*	Endangered	May 1978[i]
Harbour Porpoise			
Northwest Atlantic	*Phocoena phonoeca*	Threatened	April 1990
Humpback Whale	*Megaptera novaeangliae*		
Northeast Pacific		Threatened	April 1982
Northwest Atlantic		Vulnerable	April 1985[j]
Bowhead Whale	*Balaena mysticetus*	Endangered	April 1980[i]
Right Whale	*Eubalaena glacialis*	Endangered	April 1980[k]
Sea Mink	*Mustela macrodon*	Extinct	April 1985

[a]RANSDR — Use of NIAC (Not in Any Category) dropped in 1988 and subsequently converted. RANSDR is not a category = Report Accepted No Status Designation Required.

[b]RAISIFSD — the use of a new list "Report Accepted Insufficient Scientific Information For Status Designation" was approved at the 1990 General Meeting.

[c]Endemic to Canada

[d]Vulnerable — 'Rare' category changed to 'Vulnerable' in 1988. Dates Assigned of 1988 or earlier indicate date of original Rare status assignment. These were subsequently converted to Vulnerable at the 1990 General Meeting based on the advice of the Fish and Marine Mammal Subcommittee.

[e]Updated April 1987 — no status change.

[f]Updated April 1984 — no status change.

[g]Updated April 1987 — previous status of 'Endangered' assigned April 1985.

[h]N/A — Status Not Assigned. COSEWIC has no mandate for invertebrates. Report accepted and recommended RANSDR Status agreed to, but not assigned.

[i]Updated April 1986 — no status change.

[j]Updated April 1985 — North Atlantic stock downlisted to "Vulnerable".

[k]Updated April 1985 and April 1990 — no status change.

TABLE 2. Fish and marine mammal species for which Status Reports are in preparation, or under review April 1990.

Species	Scientific Name	Proposed Status
Fish		
Chestnut Lamprey	*Ichthyomyzon castaneus*	Vulnerable
Northern Brook Lamprey	*Ichthyomyzon fossor*	Vulnerable
Atlantic Sturgeon	*Acipenser oxyrhynchus*	?
Lake Sturgeon°	*Acipenser fulvescens*	?
Atlantic Salmon	*Salmo salar*	?
Bull Trout	*Salvelinus confluentus*	Vulnerable
Spring Cisco*	*Coregonus* sp.	?
Opeongo Whitefish*	*Coregonus* sp.	Threatened
Pygmy Whitefish	*Prosopium coulteri*	?
Pygmy Smelt	*Osmerus spectrum*	Vulnerable
Grass Pickerel	*Esox americanus vermiculatus*	Vulnerable
Cutlips Minnow	*Exoglossum maxillingua*	Vulnerable
Eastern Silvery Minnow	*Hybognathus nuchalis regius*	Vulnerable
Blackchin Shiner	*Notropis heterodon*	Vulnerable
Ghost Shiner	*Notropis buchanani*	Vulnerable
Roseyface Shiner	*Notropis rubellus*	Vulnerable
Striped Shiner	*Notropis chrysocephalus*	Vulnerable
Lake Chubsucker	*Erimyzon sucetta*	Vulnerable
Jasper Longnose Sucker*	*Castostomus castostomus lacustris*	Vulnerable
Mountain Sucker	*Castostomus platyrhynchus*	Vulnerable
Warmouth	*Lepomis gulosus*	Vulnerable
Striped Bass	*Morone saxatilis*	Endangered
Channel Darter	*Percina copelandi*	Vulnerable
Eastern Sand Darter	*Ammocrypta pellucida*	Vulnerable
Tessellated Darter	*Etheostoma olmstedi*	Vulnerable
Flathead Catfish	*Pylodictis olivaris*	?
Northern Madtom	*Noturus stigmosus*	Vulnerable
Shorthead Sculpin	*Cottus confusus*	Vulnerable
Y-Prickleback	*Allolumpenus hypochromus*	Vulnerable
Pixy Poacher*	*Occella impi*	Vulnerable
Bluefin Tuna	*Thunnus thynnus*	?
Marine Mammals		
White-beaked Dolphin	*Lagenorhynchus albirostris*	?
Harbour Porpoise (N. Pacific)	*Phocoena phocoena*	?
Baird's Beaked Whale	*Berardius bairdii*	?
Beluga Whale (W. Hudson Bay)	*Delphinapterus leucas*	
Northern Bottlenose Whale	*Hyperoodon ampullata*	?
Bowhead Whale	*Balaena mysticetus*	Endangered
Killer Whale	*Orcinus orca*	?
Long-finned Pilot Whale	*Globicephela malaena*	?
Sperm Whale	*Physeter catadon*	?
Striped Dolphin	*Stenella coeruleoalba*	?
Bottlenose Dolphin	*Tursiops truncatus*	?
Short-finned Pilot Whale	*Globicephala macrorhynchus*	Vulnerable
Pygmy Sperm Whale	*Kogia breviceps*	Vulnerable
Sei Whale	*Balaenoptera borealis*	?
Minke Whale	*Balaenoptera acutorostrata*	?
Dwarf Sperm Whale	*Kogia simus*	Vulnerable
Atlantic White-sided Dolphin	*Lagenorhynchus acutus*	?
Common Dolphin	*Delphinus delphis*	?

*Endemic to Canada
°Updated Status Report

TABLE 3. Fish and Marine Mammal Species of Interest to COSEWIC — April 1990 (Not listed by priority).

Species	Scientific Name	Possible Status
Fish		
Red (Arctic) Char[1]	*Salvelinus alpinus* ssp.	? (Landlocked populations — Quebec, New Brunswick, Newfoundland/Labrador).
Lake Herring	*Coregonus artedi*	Endangered in Lakes Erie and Ontario but widespread elsewhere.
Lake Whitefish	*Coregonus clupeaformis*	Threatened in Lakes Erie and Ontario but widespread elsewhere.
Mira Whitefish	*Coregonus* sp.	Vulnerable.
Round Whitefish	*Prosopium cylindraceum*	Vulnerable (Lakes Huron and Ontario but widespread elsewhere).
Pygmy Longfin Smelt*	*Spirinichus thaleichthys*	Vulnerable (landlocked population in Harrington Lake, British Columbia).
Chain Pickerel	*Esox niger*	Vulnerable (Quebec, New Brunswick, Nova Scotia).
Redfin Pickerel	*Esox americanus americanus*	Vulnerable (Quebec).
Chiselmouth	*Acrocheilus alutaceus*	Vulnerable (British Columbia).
Bluntnose Minnow	*Pimphales notatus*	Vulnerable (Manitoba).
Western Silvery Minnow	*Hybognathus argyritis*	? (Alberta).
Weed Shiner	*Notropis texanus*	Vulnerable (Manitoba).
Nooky Dace	*Rhinichthys cataractae* spp.	Vulnerable (British Columbia).
Liard Hotspring Lake Chub*	*Couesius plumbeus* spp.	Vulnerable (British Columbia: Liard Hotpsring).
Texada Stickleback*	*Gasterosteus* sp.	Vulnerable.
Cultus Pygmy Coastrange Sculpin*	*Cottus aleuticus*	Threatened (British Columbia).
Mottled Sculpin	*Cottus bairdi*	Vulnerable (British Columbia, Alberta).
Spinynose Sculpin	*Asemichthys taylori*	Vulnerable (British Columbia).

*Endemic to Canada
[1]Not of immediate concern

population of the Harbour Porpoise (*Phocoena phocoena*), but the report on this species will not be published at this time pending further consideration of the eastern North Pacific population.

A new list entitled, "Reports Accepted — Insufficient Scientific Information Available on Which to Base a Designation", was added in 1990. The Darktail Lamprey (*Lethenteron alaskense*) and the Bering Cisco (*Coregonus laurettae*) were placed on this list.

Acknowledgments

The Subcommittee wishes to extend their thanks to the various authors who have so generously contributed their time and talent in support of COSEWIC and I wish to thank the members of the Subcommittee for their unstinting efforts in reviewing the reports and for their helpful comments.

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Reeves, Randall R, and **Edward Mitchell.** 1989. Status of White Whales, *Delphinapterus leucas*, in Ungava Bay and eastern Hudson Bay. Canadian Field-Naturalist 103(2): 220-239.

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Status of the Darktail Lamprey, *Lethenteron alaskense,* in Canada*

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Houston, J. 1991. Status of the Darktail Lamprey, *Lethenteron alaskense*, in Canada. Canadian Field-Naturalist 105(2): 157–160.

The Darktail Lamprey, *Lethenteron alaskense*, is one of the smaller non-parasitic members of the Petromyzonidae and has only recently been reported in Canada. The only known record for the species in Canada is from the Martin River, a tributary of the Mackenzie River in the Northwest Territories.

Le premier relevé au Canada de la Lamproie à queue foncée, *Lethenteron alaskense*, l'un des plus petits pétromyzontidés non parasites, est très récent. D'après nos connaissances, cette espèce n'a été observée que dans la rivière Martin, tributaire du fleuve Mackenzie dans les Territoires du Nord-Ouest.

Key Words: Darktail Lamprey, Lamproie à queue foncée, *Lethenteron alaskense*, Petromyzontidae, status, Canada.

The Darktail Lamprey, *Lethenteron alaskense* Vladykov and Kott 1978, is one of the smaller non-parasitic members of the lamprey family (Petromyzonidae) with a maximum recorded length of 188 mm (Vladykov and Kott 1979). Individuals (Figure 1) most closely resemble the American Brook Lamprey, *Lampetra appendix*, (*see* Vladykov and Kott 1982). Adults are non-parasitic.

The species is known in Canada from a single record and was only recently described (Vladykov and Kott 1978). Vladykov and Kott (1978, 1979) referred to the species as the Alaskan Brook Lamprey, but the common name of Darktail Lamprey seems to have become more widely accepted (Vladykov et al. 1980).

Systematics

Great confusion has arisen in lamprey taxonomy. During the 1970s, descriptions for a number of new species were published and there has been no general agreement as yet as to which forms merit specific status, nor which genera should be recognized (*see* Vladykov and Follett 1967; Vladykov and Kott 1978, 1979, 1982; Bailey 1980; Robins et al. 1980).

Vladykov and Kott (1978) described the Darktail Lamprey and placed it in the genus *Lethenteron* (Creaser and Hubbs 1922). They were able to distinguish transformed specimens from those of the anadromous, parasitic, Arctic Lamprey, *L. japonica*, with which the Darktail Lamprey is sympatric. Vladykov and Kott (1978) also demonstrated that the species was distinct from the small non-parasitic American Brook Lamprey, *Lampetra appendix*, with which it is most closely related and which it most closely resembles. *L. appendix* is found only in eastern and southern North America, 2400 km from the range of the Darktail Lamprey. The Arctic Lamprey has been considered by some authors to be synonymous with the American Brook Lamprey (Scott and Crossman 1973). The American Fisheries Society did not recognize the Darktail Lamprey as a separate species in their 1980 list, but did acknowledge that this current list was somewhat arbitrary and required clarification (Robins et al. 1980). It is listed as a species by McAllister and Gruchy (1978). Vladykov et al. (1980) continued to recognize it as a distinct species and mapped its distribution.

Distribution

The distribution of the Darktail Lamprey is limited to northwestern Canada and Alaska. In Alaska, the species ranges from West Creek, a tributary of Brooks Lake, Alaska, to the Ugashik River of the Alaska Peninsula, and north to the Chatanika River of the Yukon drainage near Fairbanks, Alaska (Vladykov and Kott 1978).

In Canada, the Darktail Lamprey is known only from the Martin River (Figure 2), a tributary of the Mackenzie River in the Northwest Territories (Vladykov and Kott 1978; Vladykov et al. 1980).

Protection

There have been no special protective measures or legislation for this species in Canada except for the general protection offered by the Habitat Sections of the Fisheries Act. Elsewhere in

*Report accepted by COSEWIC 11 April 1990 — insufficient scientific information on which to base a status designation.

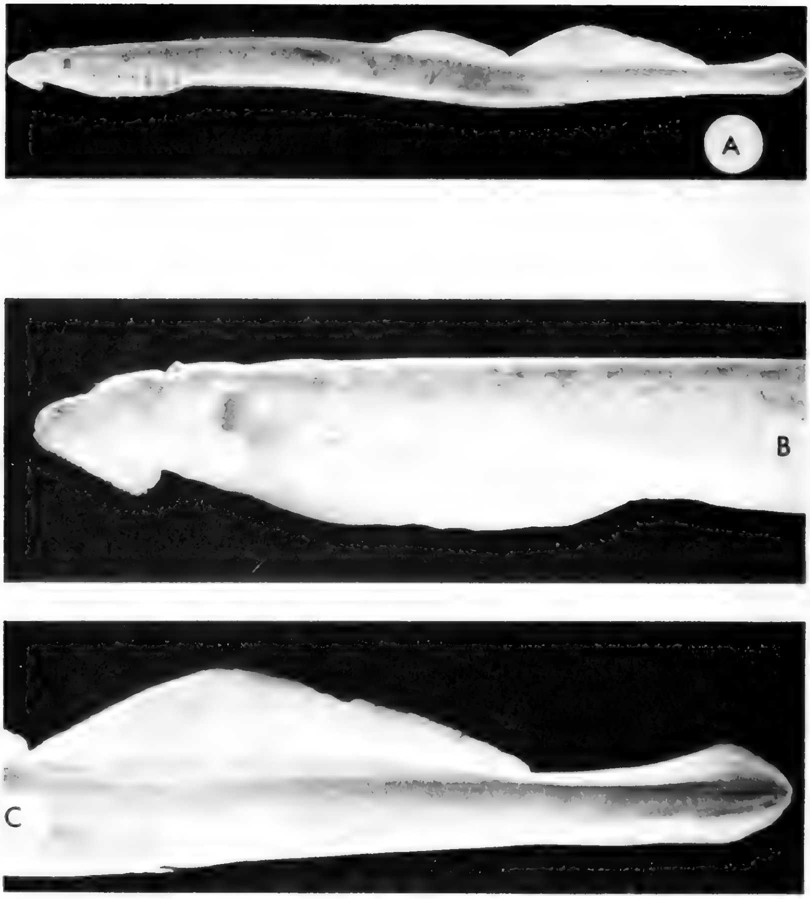

FIGURE 1. Holotype of *Lethenteron alaskense*. Courtesy of the Canadian Museum of Nature, from Vladykov and Kott (1978) [male: total length 164 mm]. (A) Lateral view, (B) Enlargement of the head, (C) Enlargement of the tail.

Canada, control measures to eliminate populations of parasitic lampreys are undertaken, but this is a non-parasitic species.

Population Sizes and Trends

There have been no population studies for this species and the information available at present is simple presence absence data. There is only one known Canadian record despite the presence of the species in the Yukon River system in Alaska. This apparently disjunct Canadian population in the Mackenzie system is separated from the nearest known Yukon system record by nearly 1800 km and the Great Divide. This anomoly might call into question the identity of the Canadian specimen(s), or it may reflect inadequate collection of lampreys in the intervening areas. The possibility also exists that location labels were mixed (D. E. McAllister, Canadian Museum of Nature, Ottawa, Ontario; personal communication)

Buchwald (1968) indicated that Arctic Lamprey are found in the Mackenzie River System, Great Slave Lake and the Slave River as far upstream as Fort Smith. He also recognized anadromous and non-anadromous forms of the species and the greater potential size of the former. These differences were apparently noticeable in the Slave River (Buchwald 1968) and have also been reported in the Yukon River (Heard 1966). The presence of the larger, parasitic form so far upstream further clouds the issue and there does not appear to be any new evidence to clarify it. The parasitic nature and larger size of the Arctic Lamprey would weigh in favour of its distinctness from the American Brook Lamprey. Also, anadromous lampreys are known to migrate long distances between fresh and saline waters and to utilize freshwater habitats as demonstrated by the Sea Lamprey *(Petromyzon marinus)* invasion of the Great Lakes.

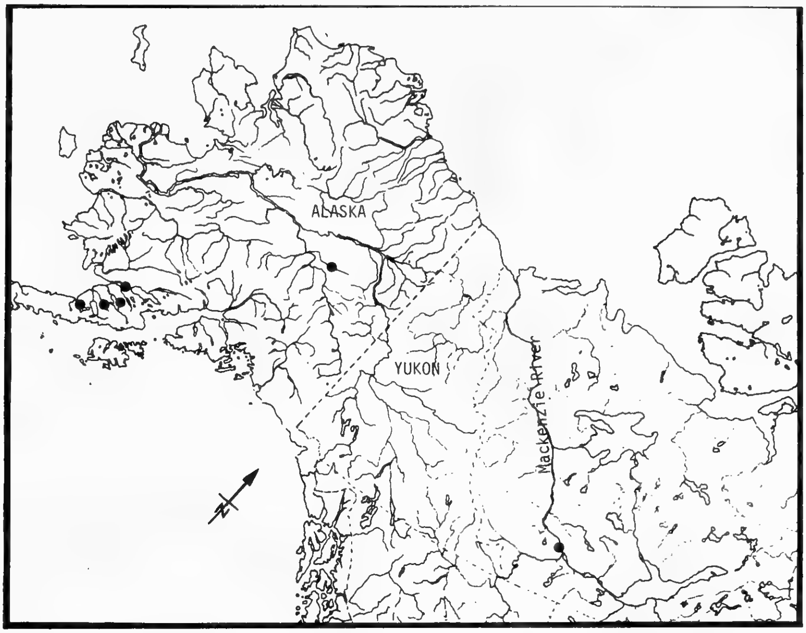

FIGURE 2. North American distribution of the Darktail Lamprey, *Lethenteron alaskense* (modified from Vladykov et al. 1980).

The presence of the smaller, non-parasitic form in the same location could auger for the presence of the Darktail Lamprey in the Mackenzie and Slave Rivers as well. Further collections need to be made, and previously collected material reexamined, to determine if the Darktail Lamprey exists sympatrically with the larger form throughout the latters' range. This seems more plausible than conspecificity with the American Brook Lamprey given the distance between the ranges of the two. The Darktail Lamprey could be a derivative of the Arctic Lamprey as the occurrence of non-parasitic derivatives in freshwater is known in lampreys (*see* Beamish 1987). Whatever its systematic status, the numbers taken at Alaskan collection sites have been small (usually 10 or less), the form is limited in its North American distribution, particularly in Canada, and can be considered rare (Vladykov and Kott 1978, 1979).

Habitat

The characteristic habitat of the Darktail Lamprey is poorly known at present. Individuals are often found in the same streams as the Arctic Lamprey (Vladykov and Kott 1978). The Darktail Lamprey is non-parasitic and restricted to freshwater whereas the Arctic Lamprey is anadromous and parasitic (Vladykov and Kott 1978).

Most streams of the Mackenzie and Yukon systems have the multiple gradient and other characteristics that Trautman (1957) and Scott and Crossman (1973) described as being suitable to lamprey for spawning, larval growth, and development (Heard 1966).

General Biology

Heard (1966) summarized life history information for both Arctic Lamprey and for the Darktail Lamprey, which he described as a dwarf, freshwater form of *L. japonicum*. Other life history details are provided by Vladykov and Kott (1978).

The Darktail Lamprey has been reported to spawn in Alaska in May, June, and early July when temperatures are above 12° C (Heard 1966). Both sexes are active in building the nest which may be 15 to 25 cm in diameter, and varying from a slight depression to 5-7.6 cm in depth. Nests are built in the shallow waters of lakes, rivers or brooks where five or six spawners per nest can be found (Heard 1966). The number of eggs per female ranges from 2200 to 3500, with a diameter no larger than 0.9 mm (Vladykov and Kott 1978). Individuals only spawn once and die shortly thereafter. Spawning behaviour of the Darktail Lamprey is thus essentially the same as that recorded for other small lampreys (Heard 1966).

The eggs hatch within a few weeks and the ammocoetes feed almost exclusively on phytoplankton (Vladykov and Kott 1979). Transformation takes place in the fall when the ammocetes are

about 150 to 210 mm in length or about four years old. The transformed lampreys move downstream and overwinter in lakes.

Sculpins (*Cottus* sp.) and minnows are the main predators of the Darktail Lamprey, feeding upon their eggs in the nesting areas (Heard 1966). However, as noted by Scott and Crossman (1973) many species of fish will take eggs from unguarded nests. Ronald and Wilson (1968) have listed parasitic infections for *L. japonicum* which is sympatric with the Darktail Lamprey.

Limiting Factors

Factors limiting to the species are unknown. The species would almost certainly be affected by any changes to water quality resulting from aquatic pollution or oil spills. Habitat disruption and degradation related to placer mining and dredging activities or hydroelectric dams could also adversely affect it.

Special Significance of the Species

As Darktail Lamprey has only been reported at one locality in Canada, it is therefore of considerable interest to the scientific community as this population is some 1800 km from its closest neighbour. The taxonomy of the species, and of the family in general, is of particular interest. Its occurrence in the Northwest Territories is a potential aid to our understanding of the geological history of this area and better understanding of the uniqueness of the species itself may provide additional insights into evolutionary processes in lampreys.

Evaluation

The status of the Darktail Lamprey remains uncertain. It has been over a decade since it was last recorded in the Martin River, Northwest Territories. This may be simply a matter of lack of specific collection effort and apparent lack of interest in the species. The species should be looked for at other locations in the Mackenzie system and in the Slave River. At present, due to our lack of information on its habitat and abundance and because of its possible restricted range within Canada, the Darktail Lamprey should be considered rare.

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Status of the White Sturgeon, *Acipenser transmontanus*, in Canada*

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Lane, E. David. 1991. Status of the White Sturgeon, *Acipenser transmontanus*, in Canada. Canadian Field-Naturalist 105(2): 161–168.

Significant populations of White Sturgeon, *Acipenser transmontanus*, are restricted to three rivers in northwestern North America, the Sacramento, Columbia and Fraser. While this species can and does enter sea water it is not an obligatory anadromous species. In British Columbia, White Sturgeon are caught by commercial, native, and sports fishermen, especially in the lower Fraser River. The present total B.C. catch is likely from 30 to 40 tonnes/year. White Sturgeon spend most time in main channel areas but move into sloughs and side channels in summer in response to temperature. The species has been reported to spawn upstream in the Sacramento River at temperatures between 7.8 to 17.8°C in spring. Fecundity is high (180 000 to 590 000) and eggs are adhesive, hatching in a week at 15°C. Growth rates are variable and appear to be climatically influenced — Columbia fish reach an average of 167 cm in 20 years. White Sturgeon are carnivorous, feeding on invertebrates and fish. Limiting factors are uncertain but temperature may be important. The White Sturgeon is the largest freshwater fish in Canada. While present populations appear healthy, the distribution in Canada is restricted to south and central British Columbia in the Fraser and Columbia Rivers where they are subject to commercial, native, and increasingly popular sport fisheries.

De grandes populations d'Esturgeon blanc, *Acipenser transmontanus*, sont confinées à trois cours d'eau situés dans la partie nord-ouest de l'Amérique du Nord, soit les fleuves Columbia et Fraser et la rivière Sacramento. Bien que l'espèce puisse pénétrer en eau salée et s'y rend effectivement, ce n'est pas une espèce anadrome par nécéssité. En Colombie-Britannique, l'Esturgeon blanc est capturé par des pêcheurs commerciaux, autochtones et sportifs, notamment dans le cours inférieur du fleuve Fraser. Les prises totales actuelles dans la province se situent probablement entre 30 et 40 tm par année. L'Esturgeon blanc passe la majeure partie de sa vie dans les chenaux principaux, mais il migre dans les marais et les chenaux secondaires l'été. On a signalé que cette espèce fraie en amont dans la rivière Sacramento, à des températures variant entre 7,8 et 17,8°C au printemps. Le nombre d'oeufs pondus est élevé (entre 180 000 et 590 000), et les oeufs sont adhésifs, l'éclosion ayant lieu au bout d'une semaine, à 15°C. Les taux de croissance sont variables et semblent être régis par le climat: les poissons de la Colombie-Britannique atteignent une longueur moyenne de 167 cm en vingt ans. L'Esturgeon blanc est carnivore et se nourrit d'invertébrés et de poissons. On ne connaît pas avec certitude les facteurs limitatifs, mais la température pourrait jouer un rôle important. L'Esturgeon blanc est le plus gros poisson dulcicole du Canada. Bien que les populations actuelles semblent en bonne santé, l'aire de dispersion au Canada est limitée au sud et au centre de la Colombie-Britannique dans les fleuves Fraser et Columbia où ils sont exposés aux pêcheurs commerciaux, autochtones et une pêche sportive qui devient plus populaire.

Key Words: White Sturgeon, Esturgeon blanc, *Acipenser transmontanus*, Acipenseridae, sturgeons, vulnerable species, Canada.

The White Sturgeon, *Acipenser transmontanus* Richardson 1836, (Figure 1) may be characterized by the following description, taken largely from Scott and Crossman (1973):

The body, in both adults and juveniles over 40 cm total length, is rounded rather than pentagonal, its greatest depth about 14% of total length. The head is large and broad, somewhat less than 25% of the total length, eyes small; the snout in adults short, bluntly rounded, its dorsal profile convex; the snout in juveniles between 25 and 50 cm is concave and elongated and often much more pointed than in larger fish. Mouth toothless, located on the ventral surface, four barbells anterior to the mouth. Gill rakers 34-36 on first arch. Fins: dorsal single with 44-48 rays, tail heterocercal, pelvic insertion anterior to anus, pectorals large rounded both paired fins with heavily ossified first rays, sections of which can be used to age the fish. No scales, body covered with patches of minute dermal denticles and five rows of bony plates especially sharp in juveniles, dorsal plates 11-14, lateral 38-48 and ventral 9-12, no plates between dorsal and caudal or anal and caudal fins. Eight or nine small plates in pairs between the anus, and anal fulcrum. No lateral line. Color: from dorsal surface to lateral plates varying between dark to medium grey often with obvious white markings, especially in adults; young often are somewhat darker. Below lateral plates, pale grey to white, juveniles and adults similar, ventrally white; fins grey.

There are only two species of *Acipenser* in British Columbia, the White and the Green sturgeon (*Acipenser medirostris*). These are

*Vulnerable status approved and assigned by COSEWIC 11 April 1990.

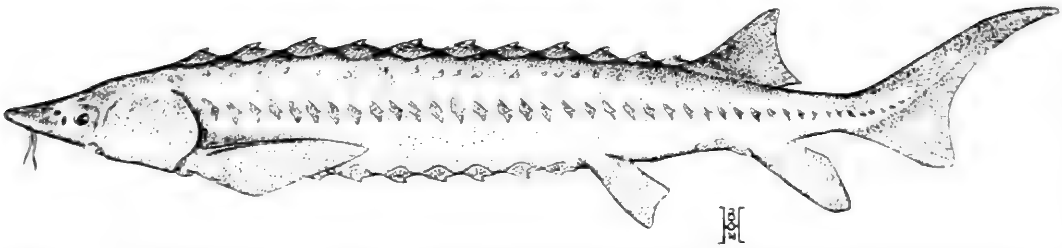

FIGURE 1. The White Sturgeon, *Acipenser transmontanus* Richardson 1836. [From Scott and Crossman (1973), by permission].

similar and apparently some intergrades occur in the Columbia River (J. Galbraith and S. King, Oregon Fish and Wildlife, Fisheries Division, Clackamas, Oregon; G. Kreitman, Washington Department of Fisheries, Battle Ground, Washington; personal communications). The most reliable method of separation appears to be the position of the anus with respect to the insertion of the pelvic fins. In White Sturgeon the anus is posterior to the pelvic insertion, while in Green Sturgeon it is in line with or anterior to the pelvic insertion (Figure 2). The lateral scute count, 38-48, tends to be higher in White Sturgeon than in the Green Sturgeon.

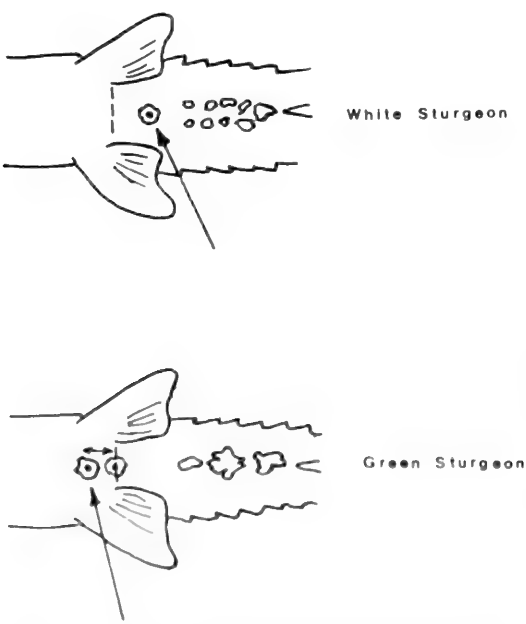

FIGURE 2. Identification of White and Green Sturgeon After Galbraith (personal communication). The anus (arrow) is posterior to the insertion of the pelvic fins in the White Sturgeon and anterior to the pelvic insertion in the Green Sturgeon

Distribution

The White Sturgeon is restricted to large coastal river systems on the northwest coast of North America. While a verified report from Alaska exists, sizable populations of this species appear to be limited to three river systems, the Sacramento, Columbia and Fraser rivers. Workers in Washington and Oregon report sturgeon populations likely exist in smaller rivers along their coasts, but no published data are available.

In Canada, White Sturgeon occur throughout most of the Fraser River system and in the upper Columbia River (Figure 3). In the Fraser River, the species has been recorded from the delta upstream to, and including, the northern tributaries [i.e., Nechako River; but there are no records from the Thompson River system (perhaps due to a lack of study)]. There are, however, anecdotal reports of sturgeon from Shushwap Lake (South Thompson system) and Clemens and Wilby (1946) report White Sturgeon "distributed along the coast . . . from the Fraser to the Skeena . . . , and in the north Thompson", with no documentation. Hart (1973) repeats the coastal distribution, again without documentation. In the Columbia River, White Sturgeon have been recorded throughout, including the Mica area; but apparently due to recent dam construction, reproducing populations may now be restricted to waters below the Revelstoke Dam. Reports of sturgeon persist from the large lakes in British Columbia, such as Okanagan Lake; however, verification by identified catches are absent.

There are valid records of "sturgeon" from the Skeena, Nass and Yukon Rivers, but in all cases where the species identification could be checked they were found to be Green rather than White Sturgeon. It is apparent that populations of White Sturgeon north of the Fraser River, if they exist, are small. There are also unsubstantiated reports of "sturgeon" from other British Columbia Coastal rivers, such as the Cowichan and Nanaimo Rivers, and Duncan Lake (Cowichan Lake?), but even if such populations existed in the past it is unlikely any White Sturgeon persist in these systems today.

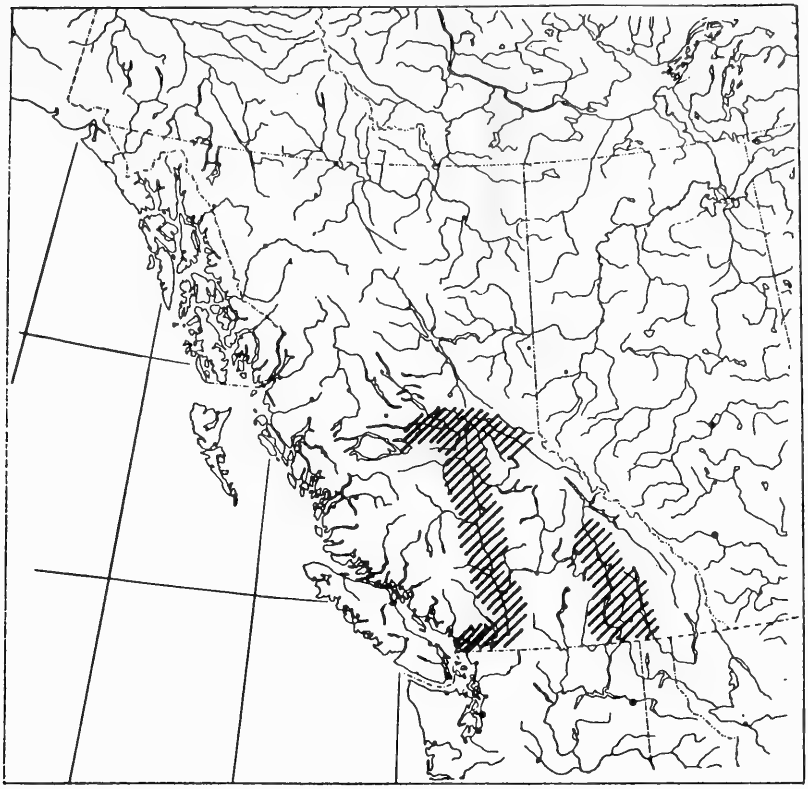

FIGURE 3. Documented distribution of White Sturgeon in British Columbia (sources as noted in text).

Most authors list the White Sturgeon as an anadromous species (Carl et al. 1959; Scott and Crossman 1973; and others); but with the exception of the San Francisco Bay area, there is only one published marine record of the species (Chadwick 1959). Galbraith, King and Kreitman (personal communications) relate that sturgeon are taken fairly often in the ocean off the mouth of the Columbia River. There are no reports of White Sturgeon in the Strait of Georgia off the Fraser River.

Where dams have been constructed on the Columbia River, White Sturgeon have become landlocked (Haynes and Grey 1981); however, where suitable passage facilities for very large fish have not been provided, upstream and reservoir populations may suffer declines [e.g. upstream of the Revelstoke Dam (H. Andrusak, British Columbia Ministry of the Environment, Fish and Wildlife Branch, Victoria, British Columbia, personal communication)].

Protection

Sturgeon are considered a sports fish by the British Columbia Ministry of the Environment, Fisheries Branch, and both a commercial and a sports fish by the Federal Department of Fisheries and Oceans. Provincial regulations vary in different Resource Management Regions in the province. One sturgeon (assumedly either a White or Green sturgeon) per fisherman per day is allowable in the region encompassing the Fraser River downstream from Spuzzum (the Lower Mainland Region), and one sturgeon per fisherman per year in the Thompson-Nicola, Kootenay, Caribou, Skeena and Omineca-Peace regions. In all regions the minimum size limit is 100 cm and in the Lower Mainland and Omineca-Peace Regions there is a 200 cm maximum size limit; fish over this size must be released.

The federal sports fishing regulations, as applicable to coastal and tidal waters, allow one sturgeon per day of greater size than 100 cm. White and Green sturgeons are not separated. The provincial requirement for a no-cost special sturgeon sport fishing permit exists in some regions and is likely to become a regulation in all regions in the near future.

All commercial catches of sturgeon are from freshwater; sturgeon can be taken by any fisherman holding an "A" or "C" commercial fishing license. There are no specific regulations regarding incidental catches of sturgeon by the Fraser River salmon gillnet fishery ("A" license). In 1975, it became illegal for sports-caught sturgeon to be sold. However, fisheries officers claim this has not restricted sales greatly, but rather has started a black market for the species.

Catch records from the late 1800s and early 1900s indicated annual sturgeon catches commonly above 100 tonnes, and in one year above 500 tonnes. Since 1913, commercial catches have been below 50 tonnes. Catch statistics for 1958 to 1984 indicate a considerable decline in the sturgeon catch except in the late 1970s (Figure 4). This sturgeon catch decline is most likely a reflection of a reduction in salmon gillnet fishing effort rather than a decline in sturgeon populations, as most sturgeon are caught as an incidental fish in the salmon fishery. An examination of the catch per unit of effort data shows a fairly constant figure over this time period, again with the exception of the late 1970s (Figure 4). The commercial catch figures do not include sports and native catches. The Department of Fisheries and Oceans 1982 estimate of the sports catch is 18 tonnes, and the 1983 estimates are 18 tonnes sports catch and 11 tonnes native catch. Native catches in 1987 and 1988 were 1.5 and 6.0 tonnes, respectively, in the Fraser River below Hope.

It is obvious that there is a fairly active and largely unregulated commercial, native, and sports fishery for White Sturgeon in the lower Fraser River. It is not at all certain that this fishery is greater than what the sturgeon population can support on a sustained basis.

Population Sizes and Trends

There has been no recent comprehensive published work on the White Sturgeon populations in Canada from either the Fraser or Columbia River. Semakula and Larkin (1968), working on the Fraser River population below Hope, British Columbia, give sustained annual yield estimates of between 36.4 and 45.5 tonnes. These are based on population estimates of 16 100 four year olds, and between 3400 and 5900 fish older than 25 years. They admit that the

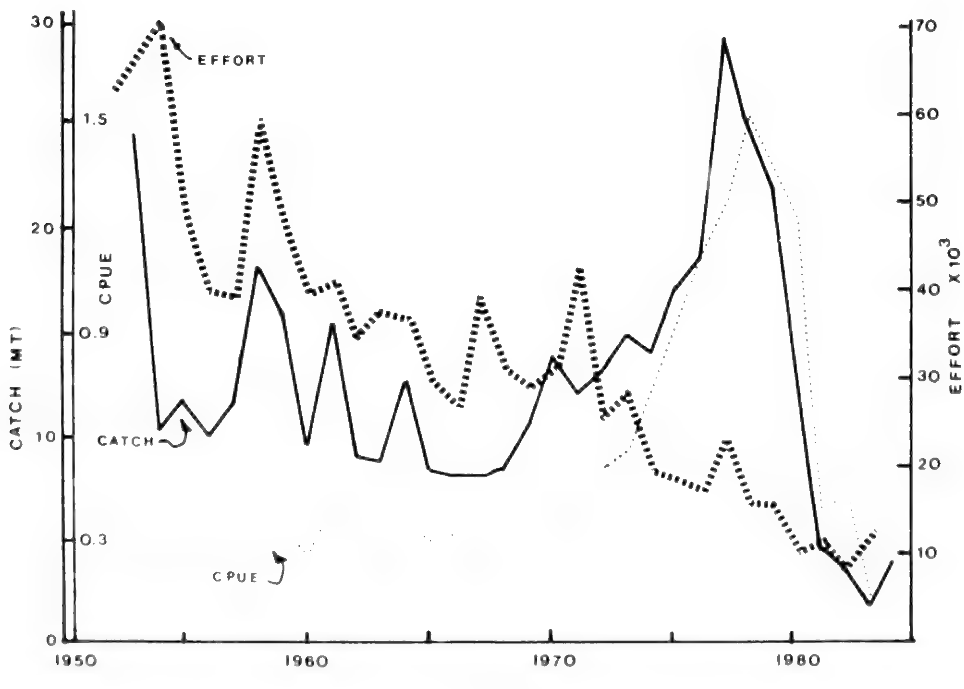

FIGURE 4. Catch statistics from the incidental sturgeon commercial fishery in the lower Fraser River, 1953-1984. Catch (solid line) in tonnes, effort (broken line) in gillnet deliveries, and catch per unit effort [CPUE] (dotted line) in kg of sturgeon divided by gillnet deliveries (data from the Department of Fisheries and Oceans)

background data upon which these estimates are made are somewhat spare. Present catches are thought to be in the vicinity of 30 tonnes, less than the Semakula and Larkin (1968) sustainable yield estimates. In the Fraser River above Hope, J. Cartwright (Fisheries Branch, British Columbia Ministry of the Environment, Kamloops, B.C., personal communication) estimates moderate populations occur in the mid-Fraser River area upstream from Boston Bar to above Lytton, and Dixon (1986) has reported on populations in the upper Fraser River system near Prince George.

Andrusak (1980), reporting on the Kootenay River White Sturgeon, gives a population estimate in the "low thousands, i.e., 3000 to 5000 fish". This estimate is based on tag returns.

In the United States portion of the Columbia River, some populations appear quite large. The 1985 catch records in the Washington/Oregon portion of the lower Columbia River exceeds 43 000 fish (King 1986). In both the Columbia River and the Sacramento River, White Sturgeon are an important sport fish.

From a review of the literature (Lane 1985), it appears that there is very little up-to-date information on Canadian populations of sturgeon and that stock assessment work is badly needed. On the other hand, from the field work underway at present in the Fraser River (by the Federal and Provincial governments and Malaspina College) and from the catch data, it is obvious that there is a fairly large number of White Sturgeon in the lower Fraser River. Andrusak's (1980) estimates indicate a smaller population in the Canadian portion of the Columbia River.

Mitochondrial DNA studies are presently being conductedby Simon Fraser University to examine possible relationships between White Sturgeon from different areas and tributaries along the Fraser River and also between the Sacramento, Columbia, and Fraser River sturgeon.

Tagging studies were conducted between 1984 and 1987 (*see* McDonald et al. 1989) to delineate movement and growth and, ultimately, to give population estimates. Approximately 1500 juvenile and sub-adult White Sturgeon were tagged in the lower Fraser River during 1985 and 1986. Preliminary reports on these studies were made by McDonald et al. (1987). The techniques necessary to culture White Sturgeon have been developed in California and are presently being modified for British Columbia conditions (Department of Fisheries and Aquaculture, Malaspina College, Nanaimo, British Columbia).

Habitat

White Sturgeon appear to spend most time in very large pools in main channel areas of the Fraser and Columbia rivers. At certain times of the year they also occupy quiet side channels and sloughs. Work on the Columbia by Haynes (1978), and Haynes and Gray (1981), has indicated that during the summer juveniles and sub-adults enter the sloughs from the main river, and during the cooler parts of the year move back to deeper water in the main stem. This has also been demonstrated on the lower Fraser River. In work currently underway, catches indicate that sturgeon enter the sloughs in the late spring when the temperature reaches 13 to 15°C. These fish, mostly juveniles (between 30 and 100 cm fork length), with a few adults early in the summer, move between the sloughs and the main channel all summer. They leave the sloughs for the main channel in autumn when the temperature falls below 13 to 15°C. There is some evidence that the summer movement between the side channels and sloughs and the main river may be in response to the tide (in the lower Fraser River) and/or diel variation in light or temperature. Upstream-downstream movement is not well defined. Preliminary tag returns indicate some movement in both directions from the tagging sites, although most returns are within a kilometer or two from the tagging site. To date, there are no tag data that would indicate either long distance movements of White Sturgeon within the Fraser River or migration to sea.

The Fraser, Columbia, and Sacramento river main stems are all turbid. The possibility that White Sturgeon prefer such waters is highly speculative; however, it can be noted that there are no verified reports of sturgeon in the clear waters of the South Thompson River.

White Sturgeon are able to tolerate saltwater and enter such areas. Sturgeon are commonly taken in the Sacramento River estuary (San Pablo Bay area) where summer salinity reaches 13.9-16.0 0/00 Cl (Kelly 1966). Unpublished records are quite common of White Sturgeon off the Columbia River, presumedly in full sea water. McEnroe and Cech (1983), report that osmoregulatory abilities of the species increase with increasing size.

White Sturgeon spawning has never been observed. Kohlhorst (1976) reports upstream spawning areas in the Sacramento River based on the capture of sturgeon larvae. Such captures occurred at the mouth of the Feather River (river km 129) upstream to river km 180, and at Colusa in the Sacramento River (km 233). The spawning sites of other sturgeon species elsewhere are described as having gravel or rock bottoms with moderate to fast currents (Dees 1961; Nikolskĭ 1961; Berg 1962; Geibel 1966; Magnin 1966). These conditions occur commonly in the Fraser River upstream of Hope, and in tributaries both

upstream and downstream of Hope; however, no reports exist of sturgeon spawning areas in British Columbia. The effect of the 1913 slide at Hell's Gate on the Fraser River with respect to limiting sturgeon migration and access to spawning areas has never been investigated, nor has the use of the present Hell's Gate fishway by sturgeon ever been reported.

General Biology

There are few publications on the biology of White Sturgeon. In the Sacramento River, sturgeon spawn in the spring (Kohlhorst 1976) when the water temperature is between 7.8 and 17.8°C. Kohlhorst (1976) indicates peak spawning occurs when the water temperature is 14 to 15°C. Specific details of the spawning habitat of White Sturgeon are undescribed; eggs are adhesive (Monoco and Doroshov 1983), and it is likely that sturgeon spawn as do other *Acipenser* species — broadcast fertilization with the adhesive fertilized eggs adhering to crevices in the substrate. Fecundity is quite high, 180 000 to 590 000 eggs per female or between 7600 to 10 900 eggs/kg female body weight (Doroshov et al. 1983). The eggs of *Acipenser transmontanus* exhibit amphibian-like holoblastic cleavage and hatch in about 7 days at 15°C.

The sac fry start feeding 7 to 10 days after hatch (Doroshov et al. 1983). Growth is quite variable in the wild. Hess (1984) has indicated that the fish reach an average size of 167 cm in 20 years; but the size range at that age is from 133 cm to 185 cm. Approximate comparisons of average growth rates from the Sacramento River in the south to the Nechako River in the north indicates the fastest growth is in the warmer water of the Sacramento and lower Columbia River compared to the lower and upper Fraser River (Figure 5). Growth of cultured sturgeon is much more rapid than in the wild (Figure 5).

Margolis and McDonald (1986) record the parasites from juvenile and subadult sturgeon taken in the lower Fraser River. Food of the White Sturgeon reported by Dees (1961), Semakula and Larkin (1958) and Fenner (1971), includes bottom invertebrates and fish, which would indicate this species is a terminal carnivore and an opportunistic feeder. Fish from the wild (lower Fraser River) brought into the laboratory will not convert to feeding on artificial pellet feeds, but will feed and grow on a diet of either live small fish or chopped pieces of larger fish (herring and trout). Laboratory hatched fish, with a total life history of pellet feeding do not require natural feeds. Buddington and Doroshov (1984) have reported on artificial feeding of White Sturgeon at the University of California. At present there are several private fish farms in the northwestern United States rearing sturgeon both for food and

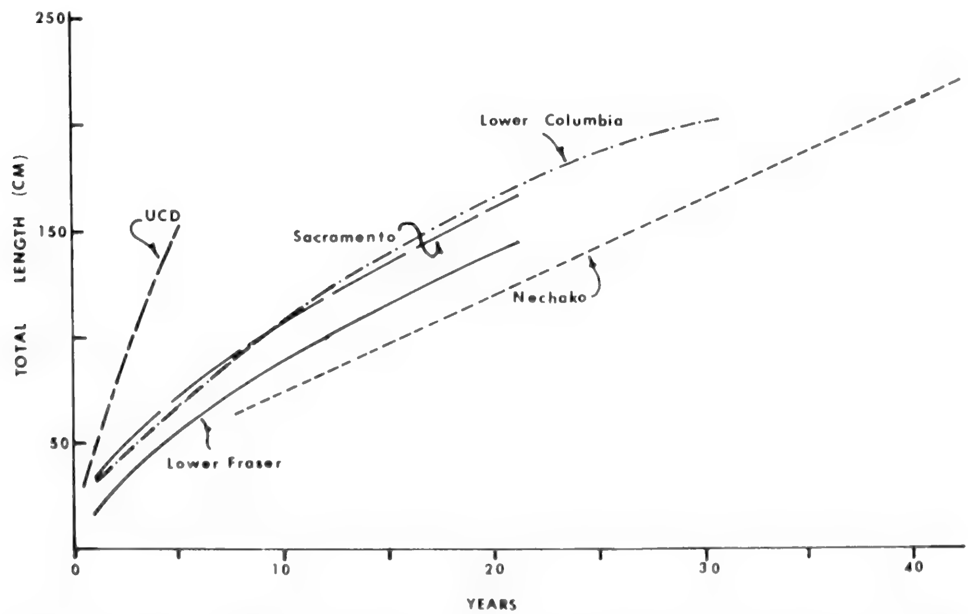

FIGURE 5. Growth in length of White Sturgeon from the Fraser River system (Semakula and Larkin 1968; Dixon 1986), Columbia River (Hess 1984), Sacramento River (Kohlhorst et al. 1980), and the aquaculture experiments at the University of California at Davis (Anonymous n.d.). Growth curves are approximate, due to the necessity of converting units

aquarium markets. In Canada, Malaspina College, Nanaimo, B.C., has a White Sturgeon culture program. In culture, it is necessary to induce ovulation and spermeation with hormone injections and to remove the eggs by Caesarean section.

Limiting Factors

It appears that the principal limiting factors in British Columbia are climate (temperature) and suitable large rivers. If, as the data suggest, the Fraser River is the most northern river to support significant populations of White Sturgeon, then it is tempting to speculate that spawning temperatures of 14 to 15°C are necessary for the production of year classes of significance. It may also be the case that larval mortality is high if the temperature during the early life history is not fairly high, at least as high as 15°C (this seems to be the case in laboratory rearing of fry). This temperature factor alone may limit the distribution of significant populations of White Sturgeon in Canada to the Fraser and Columbia rivers.

Historically, sturgeon standing crop in the Fraser River was likely much higher prior to 1910 than at present. However, examining of the catch data from 1920 onward shows no apparent decline in Fraser River stocks. Indeed, from 1910 to 1984, the highest catch per unit effort in the incidental gill net fishery occurred in 1978 (Figure 4). Since 1985, the catch data are difficult to interpret, as the correlation between the catch and the unit effort seems to be lacking. In the upper Columbia River system, the construction of dams may have a limiting effect on the sturgeon populations. So little is known of the biology of White Sturgeon that it is difficult to gauge the effects on this species of pollution in the lower Fraser River and, at present, it is impossible to name any other possible biological limiting factors.

Special Significance

The White Sturgeon occupies a unique position among all species of Canadian freshwater fish; it grows to a larger size (and perhaps greater age) than any other fish. The reported, but unsubstantiated, record is a fish of approximately 910 kg (2000 lb) and approximately 6 m (20 feet) long, taken near Mission, B.C. There is an authenticated record of a sturgeon of 630 kg (1387 lb) taken near New Westminster, B.C., in 1897 (Scott and Crossman 1973). The age of these very large fish is unknown. It is likely some fish live to an age in excess of 100 years.

It is not surprising that a fish so large is a potential major sports fish. In the Sacramento and lower Columbia rivers, the White Sturgeon sport fishery has already assumed considerable biological and economic importance. In 1985, over 1000 special permits were issued for sturgeon fishing in the lower Fraser Valley and requests for sturgeon sportsfishing guiding licenses are increasing. White Sturgeon are taken for their flesh; egg-bearing females provide caviar as well.

The acipenserids are more primitive than the modern teleost fishes. The group is represented in Canada by five species, all of the genus *Acipenser*.

Evaluation

The White Sturgeon is neither endangered or threatened by the definitions developed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) [Cook and Muir 1984]. The species, however, is likely restricted to two river systems in Canada, and perhaps has a large population only in the Fraser River. While these populations presently may be in a healthy state, they are at risk to environmental changes. The two river systems where they occur are subject to hydroelectric developments and other activities associated with urbanization and agricultural practices which could render the existing habitat unsuitable for reproduction.

The commercial fishery to which the species is subject is not well regulated and the native fishery is unregulated. The incidental catch in the salmon gillnet fishery and a popular sport fishery are additional pressures. The total harvest is probably close to or in excess of the carrying capacity of the species as it requires a relatively long time to reach maturity, probably greater than 11 years for males, and up to 26 years for females (*see* Scott and Crossman 1973). Current regulations are meant to ensure escapement of reproductive age fish and may be adequate for females. However, the 100 to 200 cm level would remove most reproductive males.

The reaction of sturgeon populations to exploitation is not fully understood, but most species seem to follow the classic pattern demonstrated by the Lake Sturgeon, *Acipenser fulvescens*, i.e., a failure to maintain population levels (*see* Houston 1987). This may be related to a synergistic product of life history factors (e.g., slow growth, late maturity, spawning less than every year) coupled with exploitation and environmental change. Given the foregoing, the species should be considered vulnerable in Canada.

Acknowledgments

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Status of the Bering Cisco, *Coregonus laurettae,* in Canada*

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Edge, Tom. 1991. Status of the Bering Cisco, *Coregonus laurettae*, in Canada. Canadian Field-Naturalist 105(2): 169-172.

The Bering Cisco, *Coregonus laurettae*, is a small coregonid of northwestern North America and the Chukotsk region of Siberia. This species is coastal and anadromous although some individuals may overwinter in the Yukon River. It is known in Canada from a single record from the Yukon River at Dawson in the Yukon Territories and should be considered as a rare species in Canadian waters.

Le Cisco de l'Alaska, *Coregonus laurettae*, est un petit corégonide du nord-ouest extrême d'Amerique du Nord et de la région Chukotsk de Sibérie. Cette espèce est un anadrome littoral, mais quelques individus peuvent passer l'hiver dans le fleuve Yukon. On a signalé la présence du Cisco de l'Alaska au Canada par un seul spécimen à Dawson sur le fleuve Yukon. Cette espèce doit être considerée comme rare dans le eaux canadiennes.

Key Words: Bering Cisco, Cisco de l'Alaska, *Coregonus laurettae*, Coregonidae, ciscos, rare and endangered fishes.

The Bering Cisco, *Coregonus laurettae* Bean 1882, is a silvery coregonid (Figure 1) only recently (1977) recorded in Canada. The species is characterized by a double flap between the nostril openings, a terminal mouth and lower gill raker counts of 18 to 25 and total counts that range from 31 to 40 (*see* Scott and Crossman 1973 for a more detailed account). The species most closely resembles the Arctic Cisco, *Coregonus autumnalis*, and has been confused with it in the past. The two species were clearly distinguished by McPhail (1966) and Alt (1973), who found the number of gill rakers on the lower limb of the first gill arch to range from 18 to 25 for the Bering Cisco and from 26 to 31 for the Arctic Cisco.

The only known record of the Bering Cisco in Canada is from the Yukon River at Dawson, Yukon Territory (deGraaf 1981).

Distribution

The Bering Cisco is known in North America from Cook Inlet in the Gulf of Alaska, north to Oliktok near the mouth of the Colville River (McPhail and Lindsey 1970; Scott and Crossman 1973). The species was thought to be restricted to northwestern North America, but a recent record from the mouth of the Chegitun River, USSR, suggests the species may be more widely distributed than previously believed along the Chukotsk Peninsula in the USSR (Chereshnev 1984).

The only record of the Bering Cisco in Canada (deGraaf 1981) is a single specimen caught on 21 September 1977, in the Yukon River at Dawson, Yukon Territory (Figure 2) which has been deposited in the Canadian Museum of Nature (formerly the National Museum of Natural Sciences) collection in Ottawa.

The Bering Cisco is generally anadromous and more common near the mouths of rivers and nearshore marine waters (McPhail and Lindsey 1970; Alt 1973). However, extensive spawning migrations have been found in several Alaska Rivers. Alt (1973) caught Bering Cisco at a number of localities throughout the Yukon River watershed as far upstream as Fort Yukon, Alaska, and the lower reaches of a tributary, the Porcupine River.

While Alt (1973) recorded the passage of Bering Cisco upstream of a fish wheel at Fort Yukon, his surveys did not document the distribution of the species between Fort Yukon and the Canadian border, 250 km upstream. More recently, Alt caught one Bering Cisco in the Yukon River about 30 km downstream of Eagle, Alaska, in September 1978. Despite this collection being about only 40 km from the Canadian border, Alt did not think there was much of a migration of Bering Cisco into Canadian waters (K. Alt, Sport Fish Division, Alaska Department of Fish and Game, Fairbanks, Alaska, personal communication).

The first record of the Bering Cisco in Canadian waters (deGraaf 1981) at Dawson constituted a range extension of 500 km upstream from Fort Yukon, and about 150 km upstream from Alt's more recent collection near Eagle. At present,

*Report accepted by COSEWIC 11 April 1990 — insufficient scientific information on which to base a status designation.

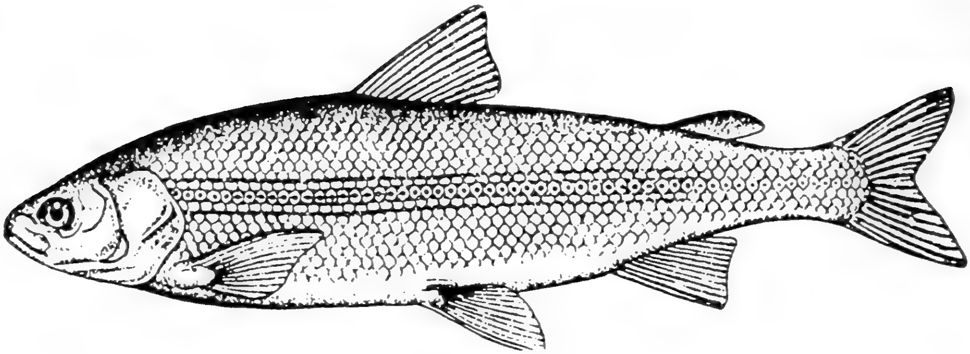

FIGURE 1. Bering Cisco, *Coregonus laurettae* (from McPhail and Lindsey 1970, by permission).

more information is needed on the movements of the Bering Cisco between Fort Yukon and Dawson. deGraaf (1981) suggested that Bering Cisco could escape detection by improper identification or, because of their smaller size, they might not be caught in commercial fishing nets. As a cautionary note, despite a large anadromous migration in the Tusket River, Nova Scotia, the Acadian Whitefish, *Coregonus huntsmani*, waas not recognized as a distinct species until the 1960s by which time the population was already decimated (Edge 1984).

Protection

There is no special protection for the Bering Cisco in Canada other than the general protection

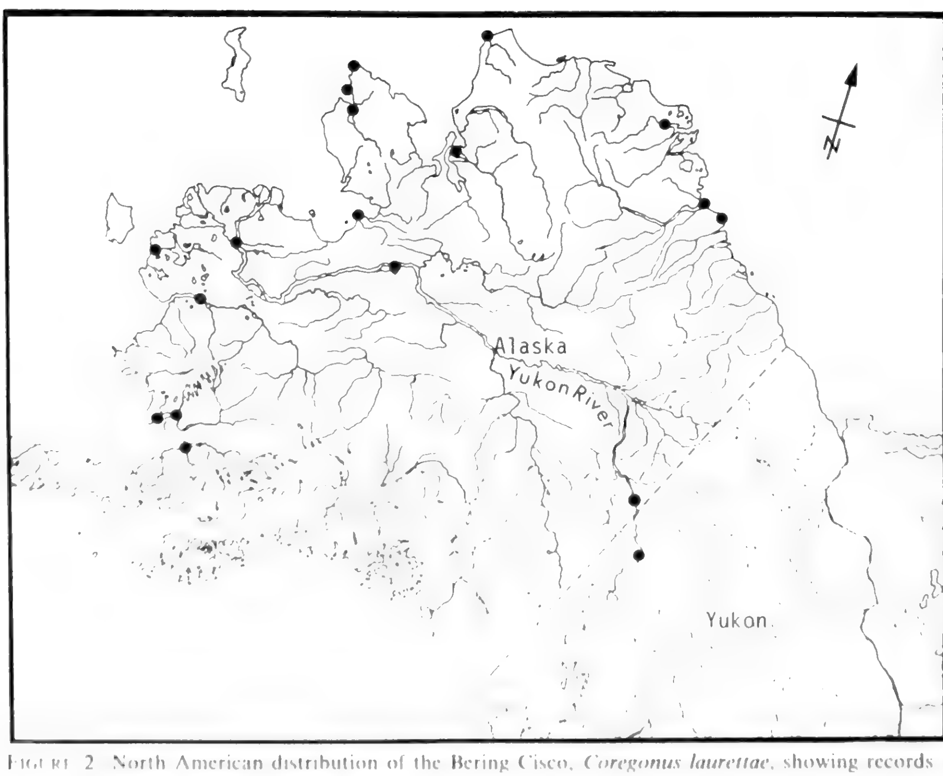

FIGURE 2. North American distribution of the Bering Cisco, *Coregonus laurettae*, showing records in Alaska and Yukon Territory, Canada

available under the habitat sections of the Fisheries Act.

Population Size and Trends

There is very little information available to evaluate the population size and trends of the Bering Cisco in Canada. A fairly large spawning run is known to occur in the Yukon River. In 1972, at the peak of this run, up to 18 specimens were taken per day in a fish wheel operating at Rampart, Alaska, and a portion of the run continued upstream past Fort Yukon (Alt 1973). While Alt (1973) found Bering Cisco migrating upstream at Fort Yukon in the Yukon River system, there was no evidence that they migrated into Canada. The fact that only a single specimen has been captured in Canadian waters would suggest the species is not common. Further studies are required to establish the number of Bering Cisco migrating into Canadian waters.

Habitat

There is little information available on the habitat of the Bering Cisco. The species is common near the mouths of rivers and in nearshore marine waters (McPhail and Lindsey 1970) and Alt (1973) has captured specimens at Port Clarence and Grantley Harbour, Alaska, at salinities from 27% to 31%. However, there are also extensive spawning migrations in Alaskan rivers and some populations of the Bering Cisco may overwinter in the Yukon River Basin (Alt 1973; Alt, personal communication).

General Biology

The Bering Cisco is known to have an extensive spawning migration in the Yukon River, starting upstream in the early spring and continuing into September. Alt (1973) reported that at Rampart, the peak of this migration occurred in early September. He also indicated that the capture of Bering Cisco in the Porcupine River on 17 June, at distance of 1610 km from the mouth of the Yukon River, suggested overwintering in the middle Yukon River.

The time of spawning and spawning grounds of the Bering Cisco are still unknown. Alt (1973) reported that the specimens caught at Rampart, Alaska, in September had large eggs and probably spawned that fall. While Alt (1973) also suggested that the Bering Cisco spawned upstream at Fort Yukon, there is no evidence that Bering Cisco spawn in Canadian waters. The specimen described by deGraaf (1981) from Dawson, Yukon, was a mature male (350 mm TL) that did not appear to be in spawning condition.

The only age and growth information on the Bering Cisco was reported by Alt (1973). Ninety-seven Bering Cisco were studied from Hess Creek, Alaska, and 17 specimens from Port Clarence-Grantley Harbour. The age-length relationships for these two areas were calculated to be $Y = 236.06 + 23.97X$ and $Y = 163.54X$ respectively (Y = fork length in mm, X = age in years) while the smallest was an immature fish at 235 mm (age III). Most Bering Cisco were found to mature at about age IV, the oldest fish sampled was age VII.

Information on the feeding habits of the Bering Cisco indicates that they fed on invertebrates such as amphipods and on small fish (McPhail and Lindsey 1970; Alt 1973).

Limiting Factors

There can be no proper assessment of the limiting factors of the Bering Cisco in Canada until more information is gathered on the species. If there is a regular migration of a small but self-sustaining population into Canadian waters of the Yukon River, it is possible that commercial fisheries for other species could threaten the Bering Cisco, as would any alteration to the aquatic habitat by industrial and/or mining developments.

Special Significance of the Species

There has been no special significance attached to Bering Cisco, although the whitefish and ciscos in general are important contributors to commercial and subsistence fisheries.

Evaluation

The Bering Cisco is a coastal, anadromous species only recently discovered in Canada. The solitary record does not provide concrete evidence of a small self-sustaining population. It is reasonable to assume that the species occurs in Canadian as well as United States waters of the Yukon River. Scott and Crossman (1973), for example, suggest the species' presence in the Yukon North slope waters. The capture of only a single specimen may suggest the rarity of the species in Canada, but also the lack of ichthyofaunal surveys in the area. Until evidence to the contrary is presented, the species should be considered rare in Canadian waters where it would be exposed to commercial and subsistence fisheries interests and habitat perturbations as a result of activities related to mineral exploitation.

Acknowledgments

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Status of the Greenside Darter, *Etheostoma blennioides*, in Canada*

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Dalton, K. W. 1991. Status of the Greenside Darter, *Etheostoma blennioides*, in Canada. Canadian Field-Naturalist 105(2): 173–178.

Greenside Darters are small members of the perch family. Their Canadian range is restricted to only three river systems in southwestern Ontario and appears to be declining. This decline may be related to habitat degradation. The availability of algae-covered rocks in riffles may be an important limiting factor, as this is preferred breeding habitat. Though the species appears to be locally abundant it should be considered vulnerable in Canada due to its restricted range and overall rarity.

Le Dard vert est un membre de petite taille de la famille des perches. Son aire de répartition au Canada est limitée à seulement trois bassins hydrographiques dans le sud-ouest de l'Ontario; il semble que l'espèce est en régression. Ce déclin pourrait être lié à la dégradation de l'habitat. Il se peut que l'absence de roches couvertes d'algues dans les petits rapides, qui sont l'habitat de reproduction préféré de l'espèce, soit un important facteur limitant. Bien que le Dard vert semble abondant localement, il doit être considéré comme vulnérable au Canada en raison de son territoire restreint et de sa rareté sur l'ensemble du territoire.

Key Words: Greenside Darter, Dard vert, *Etheostoma blennioides*, Percidae, darters, rare and endangered fishes, southwestern Ontario.

Greenside Darters, *Etheostoma blennioides* Rafinesque 1819 (Figure 1) are small, robust members of the Perch family (Percidae), averaging about 76 mm in total length (Scott and Crossman 1973). Their moderately-sized head has a triangular cross-section and holds large, prominent eyes on each side of the apex, with a small mouth below a bluntly rounded snout (Fahy 1954; Miller 1968; Scott and Crossman 1973). The fish have two closely-spaced dorsal fins, the anterior one having strong spines, while the posterior dorsal fin has soft rays which extend further than the anterior dorsal fin (Scott and Crossman 1973). Paired fins are well developed and the pelvic fins are placed anteriorly, close behind the pectoral fins (Scott and Crossman 1973).

The species' dorsal surface is olive-green or olive-brown in colour and lightens to pale green down each side. Caudal, anal and pelvic fins are also pale green in colour. Lower sides have five to seven large V-shaped marks, and fade gradually to coalesce with the white, or cream-colour ventral surface. The lateral V-shaped bars are especially prominent on young fish (Scott and Crossman 1973).

Vivid breeding colouration begins to develop in late winter and persists until the end of the breeding season. Fahy (1954) described in detail the colours of both sexes during, and after, the breeding season.

Systematic Notes

R. V. Miller (1968), in his systematic study of the Greenside Darter, recognized four distinct subspecies based on several morphological characteristics (scale and fin ray counts, degree of belly squamation, degree of opercle squamation, size of upper lip tip, presence of a distinct frenum). The northern-most subspecies, *Etheostoma blennioides pholidotum*, consists of two groups, the Missouri and the Wabash River-Great Lakes. The latter group is present in southern Ontario. These groups are not recognized as taxa by the American Fisheries Society (Robins et al. 1980), but are probably useful in the studies of fish distribution and evolution in North America. Scott and Crossman (1973) and Denoncourt (1980) do refer to them as subspecies.

Distribution

The species is found in creeks and rivers (Figure 2) in east-central North America (Hubbs and Lagler 1941; Fahy 1954; Schwartz 1965; Scott and Crossman 1973). In the eastern United States, the fish is present in New York, and the Potomac River drainage (Fahy 1954; Schwartz 1965; Denoncourt 1980). The range extends west to Kansas and south to Oklahoma, Arkansas, Mississippi and Alabama in the Mississippi River and its tributaries (Fahy 1954; Miller 1968; Scott and Crossman 1973; Denoncourt 1980).

*Vulnerable status approved and assigned by COSEWIC 11 April 1990.

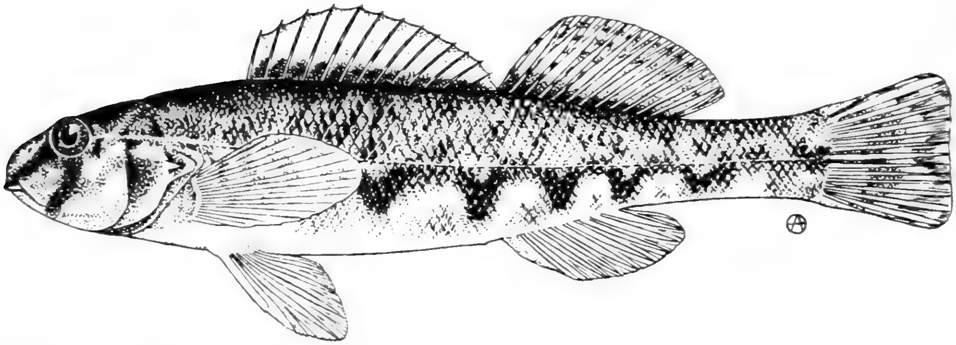

FIGURE 1. Greenside Darter, *Etheostoma blennioides*, male 82 mm, taken from the Thames River, Peel County, Ontario in 1965 (ROM 24485). Drawing by A. Odum, from Scott and Crossman 1973 by permission.

In Canada (Figure 3), the range of the Greenside Darter is limited to southwestern Ontario, where they have been found in Lake St. Clair, and in the Thames River system (Scott and Crossman 1973). Various other collections have been taken by the Ontario Ministry of Natural Resources (OMNR), the Royal Ontario Museum (ROM) and the Canadian Museum of Nature [formerly the National Museum of Natural Sciences (NMC remains the acronym for collection records)], from the Sydenham River system, a tributary of Lake St. Clair (OMNR 1981, 1982; ROM 0910, 03721; NMC 72-0191), and the Ausable River, which flows into southern Lake Huron (OMNR 1981; R0M 30796, 30797, 30698).

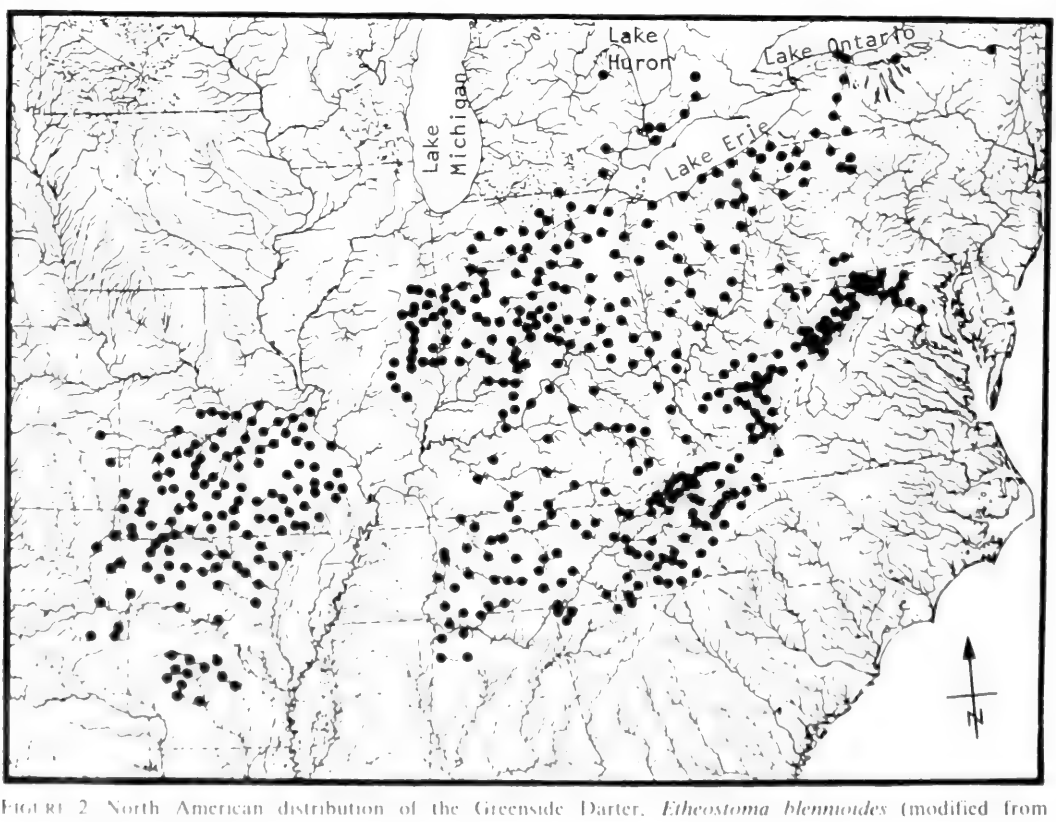

FIGURE 2. North American distribution of the Greenside Darter, *Etheostoma blennioides* (modified from Denoncourt 1980)

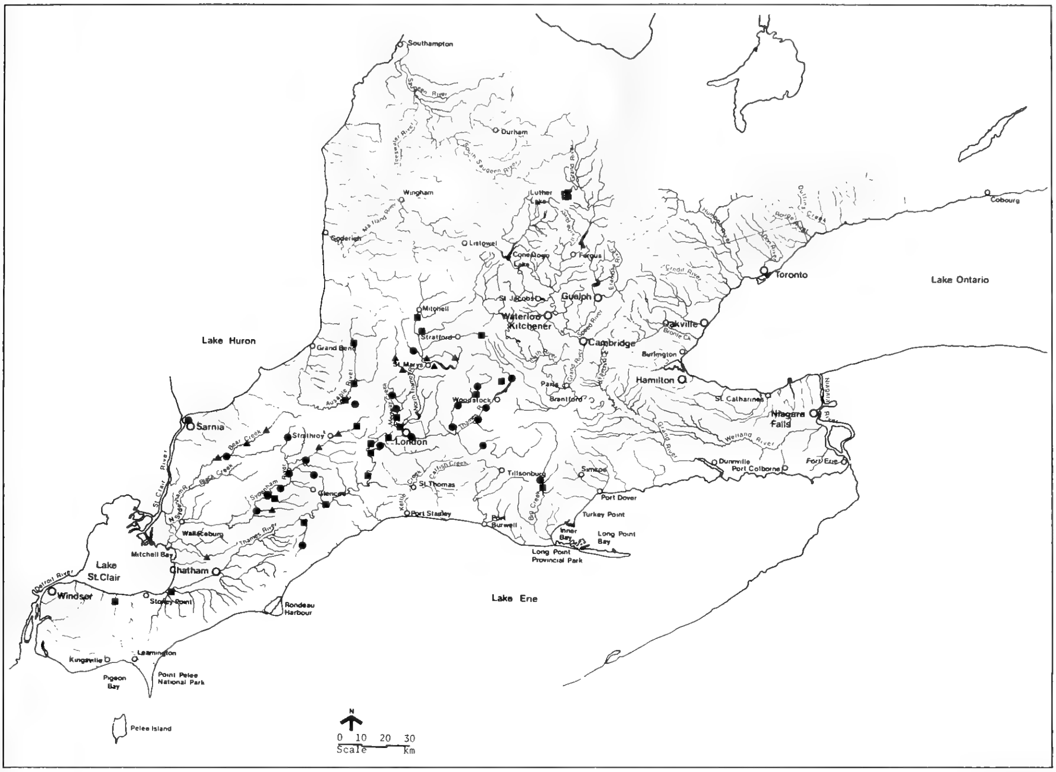

FIGURE 3. Canadian distribution of *Etheostoma blennioides*. Closed circles: Ontario Ministry of Natural Resources collections; Closed triangles: Canadian Museum of Nature (formerly National Museum of Natural Sciences) collections; Closed squares: Royal Ontario Museum collections.

A 1975 collection from Gold Creek may indicate the species presence in the area around Sarnia (OMNR 1981). The presence of Greenside Darters in Big Creek, which flows into Lake Erie near Long Point, was indicated by a 1975 collection (ROM 35564) followed by another sample in 1985 (OMNR 1984).

Protection

Greenside Darters are recognized as being of "special concern" in Kansas and Mississippi (Johnson 1987). In Canada, McAllister and Gruchy (1977) have listed the species as rare. The Fisheries Act provides general protection, although no specific protective measures are in place.

Population Sizes and Trends

The paucity of recent collection records creates difficulty in estimating sizes of, and trends affecting, Ontario populations of Greenside Darters. However, many samples were taken in the 1970s (collections to July 1987 in data bases of OMNR, NMC, and ROM). During this period, the species appeared to be locally abundant or common in some parts of the Sydenham River drainage (e.g., NMC 72-0191), the Thames River drainage (e.g., ROM 30926) as well as the Ausable River and Nairn Creek, and Big Creek.

More recent records (post-1979) show the continued presence of Greenside Darters in Haggerty and Fansher creeks of the Sydenham River watershed (ROM), Big Creek (OMNRPD 1984) and in the Thames River where they may yet be locally abundant (ROM). However, the large numbers of specimens in these collections may be the result of comparatively larger collecting efforts at a few particular sites (ROM).

In spite of these favourable indications, the species may presently be absent from several locations within their range. Scott and Crossman (1973) report that *Etheostoma blennioides* were present in Lake St. Clair, but only one record from the lake seems to exist (R0M 24909) and few come from tributaries immediately adjacent to the lake. In 1950, a ROM field survey collected 44 Greenside Darters from the Thames River in Kent County, indicating a formerly healthy abundance in that

area (ROM 21736). A 1960, a Thames River collection by the NMNS of four specimens indicates the species' presence, at least in the south-western part of the river, but does not indicate abundance (NMC 60-0523A). In the 1950s, gravel was regularly harvested from the Thames River at a principle site of this species (E. J. Crossman, ROM, personal communication). These operations may have influenced the abundance of the species at these sites at that time. No other records indicate the presence of *Etheostoma blennioides* in the area surrounding Lake St. Clair. The region is low-lying, and Greenside Darters may never have been numerous there due to lack of suitable habitat.

Several specimens were collected from various locations in the Ausable River in 1974 (ROM 30796-98) and Nairn Creek in 1976 (OMNR 1981). No Greenside Darters were ever taken from this watershed before these collections, and none have occurred in general collections since (D. E. McAllister, Canadian Museum of Nature, personal communication). The state of populations in the Ausable River watershed remains questionable, especially in view of turbidity associated with tillage.

In the United States, Van Meter and Trautman (1970) state that Greenside Darters were previously common along the southern shallow, vegetated shores of Lake Erie, but at the time of their publication the numbers were greatly reduced in many areas. The authors implied that human activities were responsible for these declines.

Habitat

Greenside Darters have been collected from various habitats but are most often found in rivers and streams of moderate to fast moving water and low turbidity (Denoncourt 1980). Abundance is greatest in deep, swift riffles with a substrate composed of rubble to boulder (Fahy 1954; Denoncourt 1980; Englert and Seghers 1983; Hlohowsky and White 1983). Descriptions of 1985 collection sites on the Thames River fit the above criteria, but the water is turbid. Rocks in these sites are generally covered with filamentous green algae (Hubbs and Lagler 1941; Fahy 1954; McCormick and Aspinwall 1983).

The critical habitat of Greenside Darters is their breeding areas, riffles with rocks covered by filamentous green algae. Trends affecting the quality and quantity of suitable breeding areas are unknown, as are the rates of habitat change. However, expanding human populations, with increased sizes of urban centers and greater demands on water resources, will clearly have adverse effects on Canadian populations of Greenside Darters. Dredging and impoundment projects could destroy the breeding habitats of this species.

Habitat is generally protected under the Fisheries Act. Restricting dredging and impoundment projects within the range of Greenside Darters could aid in the protection of the species' critical habitat.

General Biology

The life-span of Greenside Darters is typically about three years, but some individuals may live through four or even five growing seasons (Fahy 1954). Both sexes reach sexual maturity and spawn in the spring one year after hatching (Fahy 1954). Breeding occurs only after the water warms to 10.6°C and remains that high, or warmer, for at least a few days (Fahy 1954; Scott and Crossman 1973). Apparently, 10 to 12 spawning occasions over a period of four to five weeks are necessary for each female to deposit her entire egg complement (Fahy 1954). Older females produce more eggs than younger females. One-year-old females lay a total of about 370 eggs while those of older age-groups may spawn up to 1400 eggs (Fahy 1954).

Fahy (1954) observed a sex ratio of 1:1 in Salmon Creek, New York. Spawning is done in pairs; however, both sexes appear to be promiscuous and spawn with many different partners over the breeding season (Fahy 1954).

Rocks in riffles covered with filamentous algae, preferably Cladophora, are used as spawning sites (Fahy 1954; Scott and Crossman 1973). Winn (1958) commonly found the eggs of Greenside Darters on a moss (*Fontinalis* sp.), as well as on Cladophora, and once on an aquatic angiosperm (*Myriophyllum* sp.).

Fahy (1954) described an elaborate ritual reportedly performed before spawning by two males in an aquarium containing two pairs of Greenside Darters. The performance involved no physical contact, but seemed to establish dominance. Territory is selected by males; however, females choose the actual spawning site (Scott and Crossman 1973).

Fertilized eggs are demersal and adhesive (Fahy 1954; Scott and Crossman 1973). They are laid on algae close to the point of attachment with a rock, and no parental protection is given. Egg predation by an unknown predator may limit the number of offspring which survive (Fahy 1954). Cannibalism on their own eggs by adults was rarely observed by Fahy (1954), but Winn (1958) wrote that eggs laid in places other than on aquatic flora (e.g. on vertical slate or on gravel) are readily eaten by the parents and any other fishes present. Surviving eggs hatch 18 to 20 days after fertilization, in water between 13°C and 15°C (Fahy 1954; Scott and Crossman 1973).

Larvae were not found by Fahy (1954) in or near the breeding areas among the algae covered rocks. The author proposed that the small larval fish may have been swept away by the strong current in the riffles to sheltered areas in weeds, or under stones. Larvae kept by Fahy (1954) in an aquarium at 15.6°C absorbed their yolk sac in six days after hatching, and began feeding on plankton on the eighth day. Greenside Darters feed throughout the year but most heavily during the warm spring and summer seasons after spawning activities have ceased (Fahy 1954). Prey is taken from the surface of rocks in riffles, and varies as the abundances of different insect species increase and decline (Fahy 1954). Chironomid larvae are the main food for both young and adult fish (Fahy 1954; Scott and Crossman 1973). Juveniles also eat large daphnia, copepods and blackfly larvae (Fahy 1954; Scott and Crossman 1973). The prey of adults includes larvae of Diptera (Simuliidae), Trichoptera and Ephemeroptera, in season, as well as chironomid larvae (Fahy 1954).

These fish have no swim bladder, and thus spend much time resting on rocks in the riffles (Fahy 1954). A characteristic "snake-like position" is usually assumed in which the pelvic and caudal fins and caudal peduncle rest on the rock, the head is raised and the tail region is held at an angle to the main body axis (Forbes and Richardson 1920, as cited by Fahy 1954).

Movement on the rock surfaces is accomplished by sweeping actions of the pectoral fins, while the caudal fin is used as a holdfast (Fahy 1954). While feeding under rocks, the fish rotate sideways and use their caudal fin as an anchor. Movement over long distances, several centimeters or meters, occurs by sudden darting movements powered by the caudal fin. The caudal fin is also used for propulsion in strong currents (Fahy 1954). No migratory movements were observed by Winn (1958) or by Fahy (1954).

Fahy (1954) found individuals of all age-groups of both sexes in riffles throughout the year, as well as small numbers of juveniles and young adult females in quiet waters during cold fall and winter seasons when water temperatures fall to 7.2°C or less. Winn (1958), on the other hand, presumed from his seining and laboratory observations that females normally stay in pools below riffles and only move into riffles when ready to spawn. Winn (1958) stated that this discrepancy, and others, between his and Fahy's work can be resolved only by further observation, and that the behaviour of *Etheostoma blennioides* may be modified by social and ecological conditions.

Limiting Factors

Food, habitat, and breeding areas of Greenside Darters are specialized. Any disturbance of these resources would probably reduce populations of the species. Impoundments of water may reduce water flow downstream of the obstruction and flood over riffle areas upstream of the impoundment. Both situations could destroy habitat and breeding areas of this fish.

Food is restricted to benthic insect larvae. Pesticides, industrial contaminants, contaminants from agricultural runoff, and other pollutants have the potential to reduce the range of Greenside Darters, either directly by killing the fish outright or indirectly by destroying their food supply. For example, in Salmon Creek, New York, studied by Fahy (1954), the range was limited by cannery wastes carried into the stream by a tributary.

Holm and Crossman (1986) indicated that low water quality and habitat conditions in the Thames River had deteriorated markedly based on the comparison of their 1985 surveys with those conducted in the 1920s and 1940s. Turbidity and siltation had increased and stream flow rates were changed by habitat disruptions including impoundments. They also noted a general decline in numbers of species with a preference for clear, fast water and an increase in abundance of species favoured by more turbid conditions.

Special Significance of the Species

Greenside Darters are restricted to only a few major watersheds of North America and throughout their range can be classified as rare, although in some areas they may be locally abundant. Johnson (1987) lists the species as being of special concern (due to low numbers, limited distribution or recent declines) in the states of Kansas and Mississippi.

The subspecies present in Canada, *Etheostoma blennioides pholidotum*, also occurs in Ohio and New York tributaries of Lakes Erie and Ontario (Miller 1968). Van Meter and Trautman (1970) describe the populations in these rivers as greatly reduced in number, in many areas, probably due to human activities. The fish have no commercial value, and are not regarded as a sport fish, but may have some attraction as a species suitable for aquaria.

Winn (1958) observed various changes in behaviour caused by different environmental conditions. These complex interactions between genetic factors and the environment could make further studies of the Greenside Darter of considerable general scientific interest (Scott and Crossman 1973).

Evaluation

The Canadian range of the Greenside Darter is restricted to three river systems in southwestern Ontario; the Thames, Sydenham, and Ausable rivers, as well as Big Creek. Stocks of the species are greatly depleted in most parts of the range in

the northern United States. Present numbers may be reduced in the Sydenham River and parts of the Thames River drainage, and it may be extripated in the Ausable River. The breeding ground of the fish is restricted to algae-covered rocks in riffles; thus, habitat alteration or destruction could be especially detrimental to stocks of Greenside Darters. The species is short-lived, making it particularly sensitive to stock depletion. Many related species are presently threatened.

Up-to-date surveys are required to accurately determine the status of the species, especially in the Ausable River. The species appears to be particularly sensitive to changes in water conditions and until such time as more adequate information can be presented to the contrary, it should be considered vulnerable in Canada.

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Status of the Leopard Dace, *Rhinichthys falcatus*, in Canada*

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Peden, A. E. 1991. Status of the Leopard Dace, *Rhinichthys falcatus*, in Canada. Canadian Field-Naturalist 105(2): 179–188.

Only in recent years, has the Leopard Dace (*Rhinichthys falcatus*) been verified as a species distinct from the similar looking Umatilla Dace (*R. umatilla*). Both species occur in the larger main rivers of the lower Columbia Basin of Washington, Oregon, Idaho and British Columbia. Leopard Dace prefer somewhat slower segments of rivers than current-seeking Umatilla Dace. Much of the original habitat of these fishes in the Columbia River is now dammed. Judging by co-occurrence of these fishes in a reservoir in the Kootenay River of British Columbia, the species can apparently survive in disturbed habitats. However, that particular reservoir does not fluctuate in level as much as do reservoirs of the Columbia River and has steady water current in upper reaches of the reservoir where these fishes occur. It is doubtful that the species occurs in numbers similar to those before reservoir flooding. Leopard Dace are restricted in numbers in Canadian portions of the Columbia Basin: namely, the lower Similkameen River (mostly below Keremeos); Kootenay River (sympatric with Umatilla Dace in the reservoir between Brilliant and South Slocan dams); Okanagan Lake and Lower Arrow Lake. Leopard Dace have dispersed since Pleistocene glaciation into the Fraser system in contrast to the Speckled Dace (*R. osculus*) and Umatilla Dace which have not dispersed north of the Columbia System. It is found in fair numbers in the lower Fraser Valley near Chilliwack and other scattered locations including the Thompson, Nicola, West Road, Stuart and Nechako rivers plus the Fraser River below Prince George. Because of its wide distribution in British Columbia in numerous river drainages, the Leopard Dace cannot be placed in any COSEWIC category.

On sait seulement depuis quelques années que le Naseux léopard (*Rhinichthys falcatus*) est une espèce distincte de *R. umatilla*, d'apparence similaire. On trouve les deux espèces dans les grands cours d'eau du bassin du cours inférieur on et du fleuve Columbia, dans les Etats de Washington, d'Oregon et d'Idaho et en Colombie-Britannique. Le Naseux léopard préfère les portions plus lentes des cours d'eau, contrairement à *R. umatilla*, qui recherche les endroits où le courant est plus fort. Aujourd'hui, la plupart des habitats naturels de ces poissons, sur le fleuve Columbia, se trouvent dans l'emprise de barrages. A en juger par la co-occurence de ces espèces dans un réservoir de la rivière Kootenay, en Colombie-Britannique, elles peuvent survivre en milieu perturbé; il faut toutefois préciser que le niveau de ce réservoir ne varie pas beaucoup comme les autres de la rivière Columbia, et la circulation y est assez régulière. On ne sait pas si ces espèces se présentaient en quantités comparables, avant le remplissage du réservoir, mais on est en droit d'en douter. Des populations restreintes Naseux léopard habite certaines parties canadiennes du bassin du fleuve Columbia, notamment le cours inférieur de la rivière Similkameen (surtout en aval de Keremeos); la rivière Kootenay (en situation sympatrique avec *R. umatilla* dans le réservoir situé entre les barrages Brilliant et South Slocan); le lac Okanagan et le lac Lower Arrow. Contrairement à *R. umatilla* et au Naseux moucheté (*R. osculus*), qui ne se sont pas répandus au nord du bassin du fleuve Columbia, le Naseux léopard s'est dispersé, depuis le Pléistocène, dans le basin du fleuve Fraser. On le trouve en quantités appréciables dans la vallée du cours inférieur du Fraser, près de Chilliwack, et en d'autres endroits dispersés dont les rivières Thompson, Nicola, West Road, Stuart et Nechako, y compris le fleuve Fraser en aval de Prince George. En raison de sa vaste répartition en Colombie-Britannique, dans de nombreux bassins versants, le Naseux léopard ne peut être inscrit dans aucune catégorie du CSEMDC.

Key Words: Leopard Dace, Naseux léopard, *Rhinichthys falcatus*, Cyprinidae, dace, British Columbia.

Amongst Canadian fishes, the Leopard Dace, *Rhinichthys falcatus* (Eigenmann and Eigenmann 1893), though easily identified by its general appearance (Figure 1), can be easily confused with its sympatric congeners, *R. osculus* and *R. umatilla* which have a similar spotted appearance when freshly captured. Peden and Hughes (1988) found the presence of a barbel on larger specimens which protruded well outside the maxillary groove, and pelvic stays are persistently present. In contrast, *R. umatilla* has a small barbel confined within the groove and pelvic stays are absent or weakly developed. *Rhinichthys falcatus* has a more slender appearance, larger fins with delicate appearing membranes and falcate distal margins on dorsal and anal fins (more rounded fins on *R. osculus* and most *R. umatilla*). The scales near the tail of *R. falcatus* appear larger, with 51 to 63 (mean 55) scales on the lateral line (usually more in *R. umatilla*). There is an average of 26 scales

*Report accepted by COSEWIC 11 April 1990 — no status designation required.

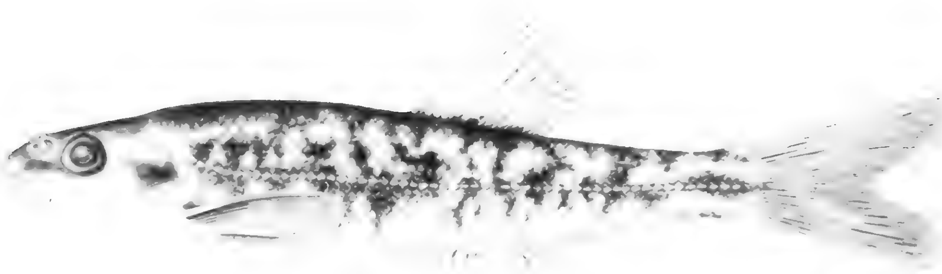

FIGURE 1. *Rhinichthys falcatus* (58 mm SL, UBC 56-573) from Nazko River, Fraser River Drainage. Drawn by Karen Uldall-Ekman.

around the caudal peduncle (average 32 to 36 in *R. umatilla*). Many *R. falcatus* have white tubercles on the head or near the tip of each scale giving an appearance of there being regular rows of tubercles along the back. Such tubercles were not observed on other species of dace that we studied.

Distribution

Rhinichthys falcatus inhabits the Columbia and Fraser systems. Distributional records are indicated in Figures 2 and 3.

United States

Washington, Oregon and Idaho: *Rhinichthys falcatus* inhabits the main stem of the Columbia drainages including the full length of the Columbia River from its estuary to the Canadian border. This includes lower reaches of the Snake, Willamette, Umatilla, John Day, Malhuer, Clearwater, Payette, Boise, Bruneau and Similkameen rivers. Simpson and Wallace (1978) and Lea et al. (1980) describe waterfall barriers (*i.e.*, Shoshone Falls, Spokane Falls) which prevent dispersal into upstream portions of the Columbia River Basin. Present day construction of dams would appear to further restrict genetic interchange between tributary drainages and prevent natural restocking of lost populations. There are records from the Cowlitz, Yakima and Walla Walla river systems (records from upstream drainages of the Deschutes River need verification).

The Similkameen River population of Washington may be of major significance to Canadian populations because the species occurs in large numbers immediately below the Canadian border and may act as a genetic reservoir for immigrants into Canada (Hughes and Peden 1985; Peden and Hughes 1988). Presently, this population is isolated from downstream populations by a dam and waterfall above Orville, Washington.

British Columbia

Columbia System: Rhinichthys falcatus is known from four areas within the Columbia River system (Figure 2); namely, Similkameen River, Okanagan Lake, Arrow Lakes, and the reservoir between Brilliant and South Slocan dams on the Kootenay River. Each river population occurs sympatrically with *R. umatilla*. Peden and Clermont (1989) discuss water temperature within the Columbia and its association between large lakes and rivers. The species tends to be restricted to portions of rivers with August temperatures between 15° and 18°C. Except for the Similkameen River, habitats inhabited by *R. falcatus* are modified by waters passing through large lakes and are less influenced by erratic runoff from summer snowmelt. Lake habitat complicates the issue of temperature preference, because isolated bays can warm quickly or the fish may select preferred micro-habitats. There are few data on habitat preference of *R. falcatus* in lakes.

Similkameen River: Peden and Hughes (1988) indicate that specimens of *R. falcatus* known from Canadian portions of the Similkameen River are small juveniles largely found between Keremeos and the American border. We have not located large Canadian adults to indicate significant reproductive populations. However large specimens were found with juveniles in portions of the river with reduced current above Nighthawk, Washington. Large adults, but no juveniles, were also found in faster current below Nighthawk (Hughes and Peden 1985) in sympatry with *R. umatilla* and provide evidence for each form having separate status as biological species.

Kootenay River: Peden and Hughes (1988) recently discovered sympatric populations of *R. umatilla* and *R. falcatus* in the reservoir between Brilliant and South Slocan dams on the Kootenay

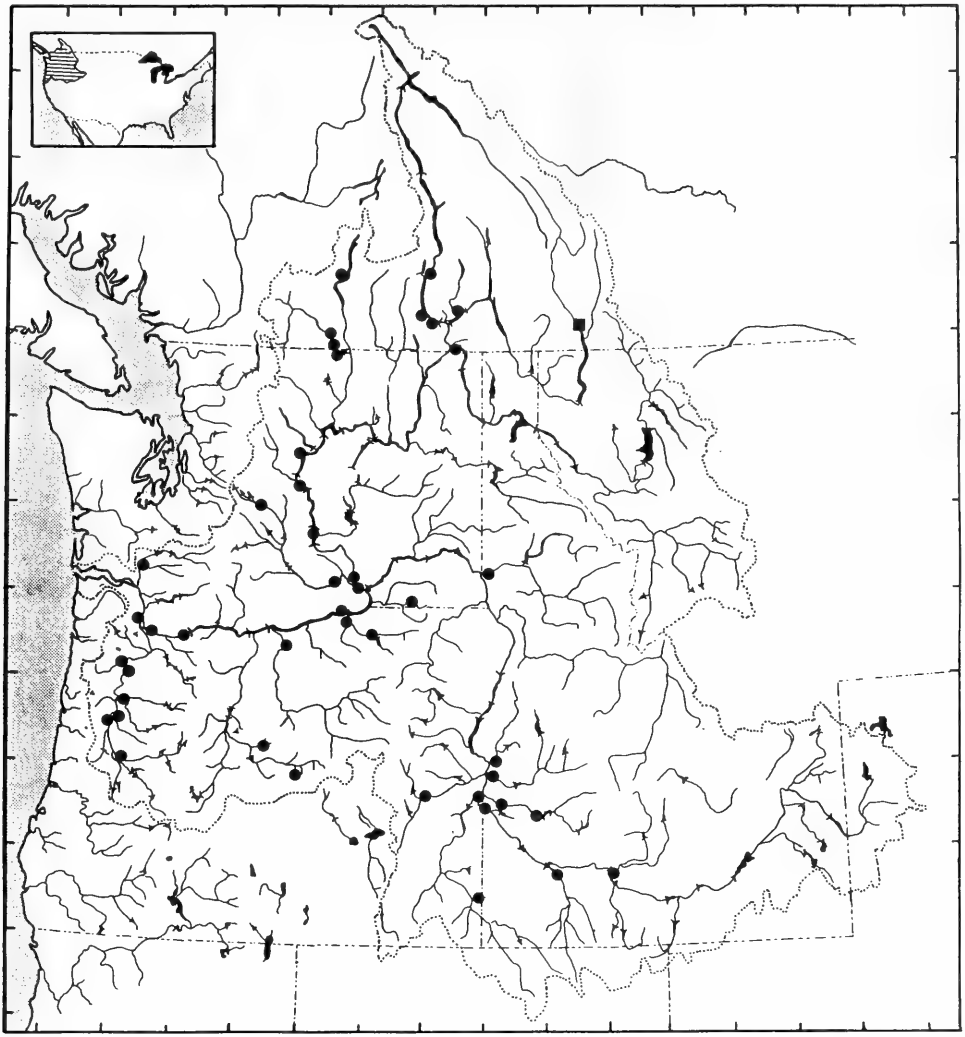

FIGURE 2. Map showing the distribution of *Rhinichthys falcatus* in the Columbia River drainage. Note: two records in the Upper Deschutes System of Oregon need verification. The darkened square shown in the upper Kootenay River represents a record shown on a distribution map by Scott and Crossman (1973), but has yet to be confirmed.

River. Peden and Clermont (1989) provided evidence that these populations are probably natural ones trapped at the time of impoundment rather than originating from other sources. A few individuals with intermediate characters may be hybrids and their existence should be studied (Figure 4). Only 15 specimens of *R. falcatus* were found after 20 hours of sampling, suggesting that this population is small.

Okanagan Lake: There have been persistent reports of *R. falcatus* from Okanagan Lake (Carl et al. 1959; Scott and Crossman 1973). We sampled both Okanagan Lake and River, but found only a few specimens in the lake, opposite Kelowna. They occurred on stoney beaches having shallow slope with beds of the water reed, *Scirpus acutus*, occurring offshore. In our judgement the Okanagan River may have been too warm for the species.

Arrow Lakes: Rhinichthys falcatus is well known from the Arrow Lakes (Carl et al. 1959; Scott and Crossman 1973). We sampled the same locations recorded for museum collections of the species and found *R. falcatus* to still be there.

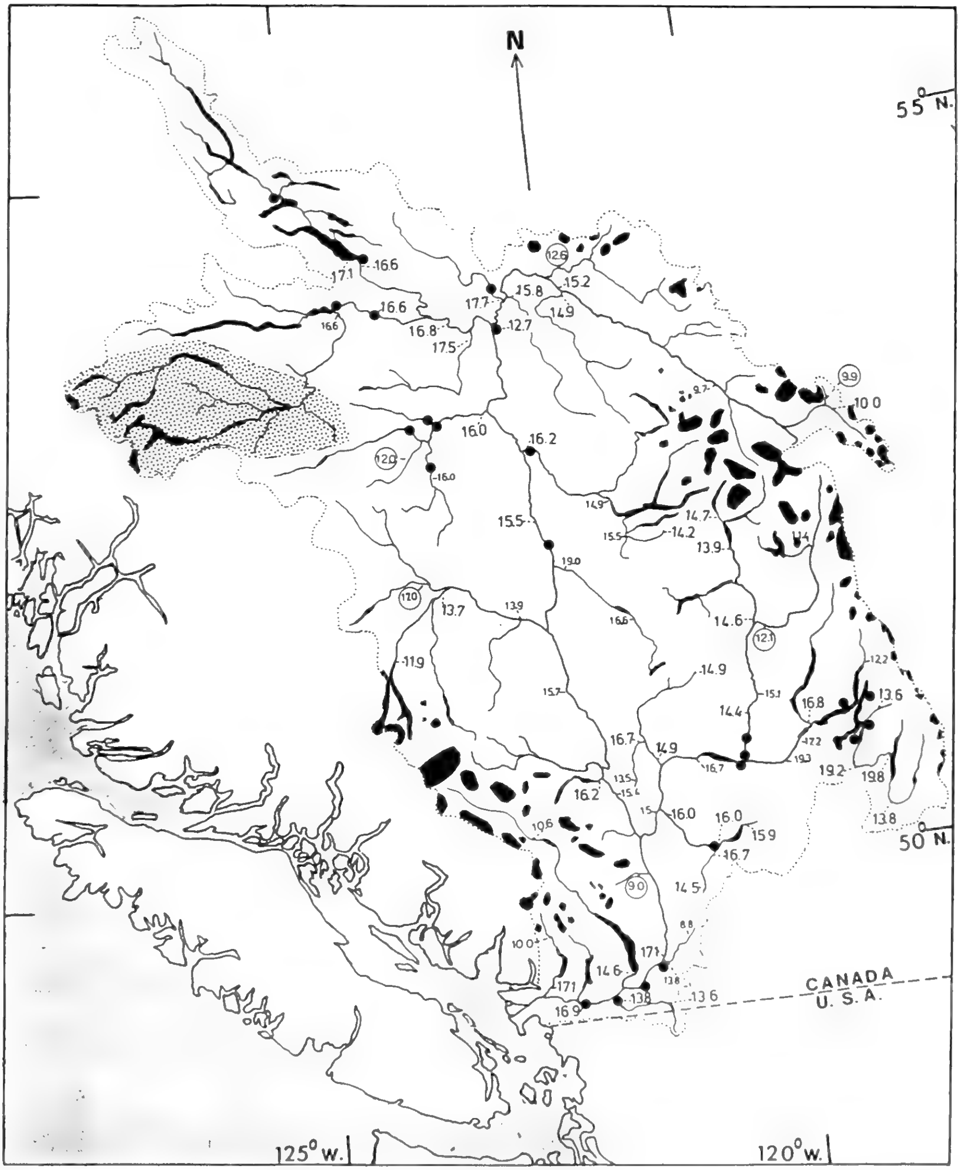

FIGURE 3. Distribution of *Rhinichthys falcatus* (darkened circles) in the Fraser River Drainage. Shaded areas indicate territory outside the drainage basin, coarse stippled area indicates portion of Nechako River drainage now diverted directly to the Pacific Coast after construction of the Kenny Dam, thickly blackened portion of rivers indicate major lakes (not named here). Numbers indicate average August spot water temperatures in °C (Environment Canada 1977). Dark patches with white stippling (not touching main rivers) indicate areas of permanent snow packs. Numbers enclosed within circles represent average temperatures based on fewer than six temperature readings.

However, the Arrow lakes are now flooded by Hugh Keenleyside Dam with an associated wide amplitude of manipulated water levels. There is much erosion of the shoreline with windswept wave-wash creating turbid inshore waters. Although there are no quantitative data for comparison, staff of the Royal British Columbia Museum sampled many sites on Arrow Lakes, but found only about a dozen specimens at four locations, suggesting the species is sparcely

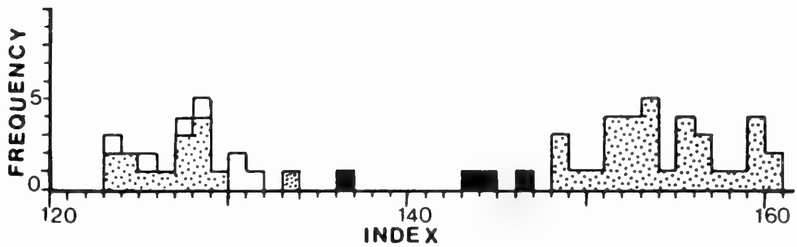

FIGURE 4. Character index representing *Rhinichthys falcatus* (individuals sorting out between 123 and 133) and *R. umatilla* (between 148 and 160) from the reservoir between South Slocan and Brilliant dams. Stippled bars are sympatric individuals of both species, solid bars are apparent intermediate individuals. The open bars are allopatric *R. falcatus* from lower Arrow Lake. The individual sorting out at 133 appears to be an atypical *R. falcatus* from the mouth of the Slocan River (indicated by coarse stippling). Data taken from Peden and Hughes (1988) where the character index is described in detail.

distributed. August temperatures of the Columbia River near Castlegar (below Arrow Lakes) average near 14.5° C; however, lake temperature upstream from here may differ. Such temperatures below the outlet of Lower Arrow Lake suggest this area is cooler than other habitats that the species occupies.

Pend d'Oreille River: Rhinichthys falcatus is reported from the Pend d'Oreille River (Carl et al. 1959); however, this river is completely altered near the international border by large dams (Peden and Clermont 1989). We observed old samples labeled as *R. falcatus*, but they were too small to determine if they were *R. umatilla* or *R. falcatus*. We also captured a larger specimen in the reservoir below the mouth of the Salmon River which may have been *R. umatilla* (identified on basis of number of scale pockets on this otherwise damaged specimen). The survival of these fish in the Canadian portion of the Pend d'Oreille River is uncertain. Future work is needed to verify if *R. falcatus* or *R. umatilla* are still present (and if so, where?).

Fraser River System: Although the only Fraser River populations that we have sampled are those from the area between Chilliwack and Hope, British Columbia, we have also had reports of *R. falcatus* from other areas of the Fraser Drainage where the species was previously known to occur. Given that public pressure from the salmon industry has discouraged building of hydro-electric dams, and therefore much of the Fraser River is relatively unmodified compared to the Columbia River, we have no reason to suspect that the overall distribution of *R. falcatus* to be greatly altered during historic times. Obviously, local changes can be expected.

Rhinichthys falcatus has been found in the following major areas (*see* Figure 3): Fraser River — Mission to Hope and near Williams Lake to Prince George; West Road River System; Nechako River; Stewart River System; Salmon River System; Thompson River System (North and South Thompson River); Nicola River system, and the Shuswap River system (including Shuswap and Mara lakes).

These localities are characterized by August water temperatures between 15° and 18° C (Figure 3). Such areas are separated by long distances from snow pack areas, or as in the case of Shuswap Lake populations, the waters are obviously warmed as they pass through the lake. We do not know if major rivers such as the Chilcotin River have been properly sampled, but August temperatures in the 13° to 14° C range suggest exclusion of *R. falcatus*. Much of the Fraser and Thompson rivers are deeply cut into their valley floors. Consequently, many secondary rivers and streams may have impassable rapids that impede dispersal of the species onto the plateaus along the sides of the main rivers.

Protection

There is no special protection for *R. falcatus* other than existing federal and provincial regulations governing environmental quality. The species does not occur in existing parks, or in ecological or other forms of protective reserves. (*See* Peden and Clermont (1989) regarding a general discussion of protective measures in the Columbia System.)

Population sizes and trends

Few data are available on population sizes and trends for *R. falcatus*. My impression for the Canadian portion of the Columbia Drainage is

that populations are very small, with that of the Pend d'Oreille precarious, that of the Kootenay River small and endangered, the Similkameen population at very low density (abundant across the border in Washington State), and those of Okanagan and Arrow lakes reduced in density but probably persistent.

Populations of the Fraser system are probably stable in numbers. However, there has been virtually no long term sampling to determine population sizes and trends. Gee and Northcote (1963) found *R. falcatus* numerous in a field study during 1961 and 1962 in the area of the Fraser River between Chilliwack and Hope, British Columbia. Staff from the Royal British Columbia Museum visited the same area in the summer of 1988 and found the species still abundant. Given the large areas of known habitat in the upper drainages of the Fraser River and the fact that environmental consultants have reported the species in the area of the Thompson River system at least, I suspect the species continues in satisfactory numbers. Obviously, long term monitoring of *R. falcatus* should be encouraged.

Habitat

Rhinichthys falcatus occurs in rivers with slow or weak current [less than 0.5 m sec (Gee and Northcote 1963)]. It is associated with rivers, but occurrences in Okanagan, Arrow and Shuswap lakes are exceptions. Potential habitat in the Fraser system is widespread, provided that conditions of temperature, bottom substrate, water flow, and absence of pollutants are met. In the United States, the species' habitat is unavoidably associated with dams and reservoirs that are different in character to its oligotrophic lake habitat in Canada.

Because I have captured the species mostly in the southern parts of its range in British Columbia, and each location where they were found differs greatly, I shall describe each separately after treating some general environmental parameters.

Summer Temperature: Peden and Clermont (1989) describe temperatures of the Columbia System in detail. Although average spot August temperatures where *R. falcatus* occurs average near 15° to 18° C, rivers such as the Similkameen with direct runoff from mountain peaks may have tremendous variation depending on weather conditions. Rivers such as the lower Kootenay and Columbia have consistent temperatures which are moderated as water flows through large lakes. Rivers of the Fraser System probably act similarly, (Figure 3; *see also* Peden and Clermont 1989). Most interestingly, snow packs dominate in the upper Columbia, upper Kootenay, upper Fraser (above Prince George), east of Shuswap, and coastal mountains where August river temperatures below 14° C are common and no *R. falcatus* have been found. The vast central area of the Fraser River is remote from permanent snow packs, tends to have warmer temperatures, and have populations of *R. falcatus*. Obviously, the portion of the Fraser River passing through coastal mountains will entrain warmer water (and dace?) from the interior.

Because of stratified summer temperatures according to depth, it is difficult to assess August temperature preferences of *R. falcatus* in lakes. Within the Columbia drainage of British Columbia, Okanagan Lake is undoubtedly the warmest habitat for *R. falcatus* and the Arrow Lakes are coldest. As indicated in Figure 3, the Shuswap area possesses the warmest habitats within the Fraser system where *R. falcatus* occurs. Takla, Trembluer, Stuart; Francois, Shuswap, Adams, Mara and Nicola lakes probably modify temperatures in Stuart, Nechako, Thompson, South Thompson, and Nicola rivers where *R. falcatus* is found. The West Road River was described in one set of collection data as a wide river. Numerous lakes in Tweedsmuir Provincial Park are now dammed and diverted directly to the coast (Figure 3), and probably influenced the Nechako River before impoundment. Temperatures of the Chilcotin and Lillooet rivers are apparently too cold.

Winter Temperatures: Within the Columbia River system, the Similkameen River averages 0.6° C in January where *R. falcatus* occurs and the river may freeze. In contrast, the Kootenay River averages near 3° C and the river water rarely freezes (Peden and Clermont 1989). Moreover, spring warming occurs earlier (March). Although Environment Canada (1977) data are not analyzed in detail here, upper regions of the Fraser River freeze solidly and spring warming occurs more than a month later (i.e., April or May).

Spring Flooding: The cycle of spring snow melt is more fully described by Peden and Clermont (1989). In contrast to the Kootenay River and Arrow Lakes populations where dams alter seasonal sequence of flooding and low water periods, other locations in British Columbia with *R. falcatus* have a natural cycle. Periods of high water levels will be near times of spring or summer spawning and low water periods will occur in fall and winter. Thin layers of algae on rocks along the three foot depth of shoreline where *R. falcatus* occurs support insect larvae on which the species feeds. This shallow band of productivity undoubtedly shifts as water levels lower or spring turbidity clears.

Dissolved Solids: Although Peden and Clermont (1989) were concerned about nutrient loading in the Columbia System, this factor is probably less important at this time for *R. falcatus* in the Fraser River. Except for the Kootenay River below Nelson, the species inhabits areas less subjected to municipal effluents. The exceptional situation of Okanagan Lake is discussed below.

As for the Fraser System, effluents from the City of Kamloops may affect downstream habitat of the Thompson River and that of Prince George may affect nearby Fraser habitat with *R. falcatus*. Despite these localized conditions, the species as a whole is probably less affected by municipal or industrial effluents than in the Columbia River (but see exception below). Other issues of logging or mining could have greater significance.

Northcote and Larkin (1963) characterize the turbidity of most interior lakes of the Columbia and Fraser drainages in British Columbia as being between 75 to over 300 ppm dissolved solids. Waters of coastal and high mountain areas where the species does not occur are below 75 ppm. Populations in the Fraser River near the coast are obviously influenced by waters of higher dissolved solids carried from the interior.

Columbia Habitats

Similkameen River: Similkameen River habitats are briefly described by Hughes and Peden (1983, 1984), Peden and Clermont (1989), and Peden and Hughes (1988). *Rhinichthys falcatus* was confirmed to occur with *R. umatilla* in the lower portion of the river below Keromeos. *Rhinichthys umatilla* also occurred upstream as far as Otter Creek. Numerous young-of-the-year were seined during September and October in back water pools, but no adult *R. falcatus* were captured on the Canadian side of the International Border. Immediately downstream, near Nighthawk, Washington, adult and juvenile *R. falcatus* were found in large numbers where slower river flow allowed fine sediment to settle on stones. When using an electro-shocker, we observed *R. falcatus* darting out of the fine sediment as frequently as from the stones under which the species often hides. Downstream from this location, the river bottom is much more rocky with current fast enough to remove the fine sediment. Relatively large adults were found here, but no juveniles of *R. falcatus*.

In general, this lower portion of the Similkameen is subjected to direct runoff of spring snow melt from high mountains, and has a wide flood plain on the Canadian side of the border. Except in spring flood, the water is very clear. The lower American portion of the river where *R. umatilla* and *R. falcatus* were found is rocky with some portions having bedrock. The lower Canadian portion consists largely of gravel or stoney bars that are very clean and probably shift during flood. Consequently, such habitat may be less stable for sheltering dace. I believe inflatable rafts should be used to find any pockets of habitat sheltering adult *R. falcatus* and *R. umatilla*, if we are to confirm whether sustainable populations occur within Canada.

Kootenay River: The section of the Kootenay River now possessing *Rhinichthys falcatus* is very restricted (Peden and Hughes 1988). This area below the present South Slocan Dam corresponds with the section of the river locally known as Slocan Pool. Judging by the configuration of the river and the presence of gravel bars on the river bottom when the reservoir is lowered, appropriate slow water habitat associated near the pools probably occurred here before reservoir construction. *Rhinichthys umatilla* and *Cottus bairdi* were apparently trapped above South Slocan Dam at time of river inundation (Peden and Hughes 1988; Peden and Clermont 1989). Populations of *R. falcatus* in the same area are probably indigenous. Upstream, Bonnington Falls probably acted as the prehistoric barrier to dispersal.

Today, this population of *R. falcatus* inhabits a reservoir that is designed for power generation, but it too small for significant water storage. Thus, fluctuation of water level varies up to about two meters in a 24-hour cycle depending on needs to generate power. Upstream storage reservoirs such as Cora Linn and Libby dams buffer seasonal floods.

Rhinichthys falcatus occurs in very reduced numbers in this section of river. We sampled with back-pack electro-shockers for 20 or more hours in the reservoir (8 hours of shocking in the Slocan Pool area) in three years but found only 15 specimens. Many more *R. umatilla* are found nearby; for example, in the mouth of the Slocan River. Because of the possibility of hybrids (Peden and Hughes 1988), there could be genetic swamping by *R. umatilla* if *R. falcatus* numbers drop too low (Figure 4).

Before construction of Brilliant and Hugh Keenleyside dams, *R. falcatus* populations of the Kootenay River may have had contact with those in the Columbia River and Arrow Lakes area. Old photographs indicate the Columbia River was relatively slow above Castlegar and Robson near the outlet of Arrow Lakes. Today, the Hugh Keenleyside Dam and pulp mills at Castlegar may have made this section of river unsuitable for *R. falcatus*.

Arrow Lakes: Rhinichthys falcatus is known largely from Lower Arrow Lake with specimens being found above Farquier, Renata and Shields,

British Columbia. The original lake is dammed and serves as a storage reservoir, with a huge amplitude of water level often out of phase with natural cycles of spring flooding and fall or winter periods of low water. During recent field trips in September and October, the lakeshore looked barren, with little vegetation. Wind swept waves on the lake disturbed silt along much of the inshore area increasing turbidity. In several of the areas where we found juvenile *R. falcatus* (near Renata and Farquier) the water was very silted from wave action so that we could not visually see the bottom (up to one meter sampling depth). Other extensive areas of steeply inclined rocks possessed clearer water from which *Rhinichthys cataractae* and *Cottus asper* were captured but no *R. falcatus* were observed.

Adult and juvenile *R. falcatus* were taken during September-October in 1987, and again in 1988, at the mouth of Shield Creek where large rocks without silt produced clearer water. Huge boulders of 0.7 to 1.7 m diameter were piled up high on the beach of the lake. The creek bed apparently was well flushed out during spring flood, however the flow was a mere trickle at the time of our October visit. In a small bay at the creek mouth where the shore was steeply piled with round rocks were a few depressions up to 1.3 to 2 m depth that possessed an accumulation of bright green algae. *Rhinichthys falcatus* was taken in small numbers at depths up to 1.3 m (maximum depth reached with electrodes and dip net).

In general, it is difficult to assess preferred habitat for this species in a natural lake so heavily impacted by a dam and because of the spotty known distribution of *R. falcatus* within the lake.

Okanagan Lake: There are no large rivers to flush Okanagan Lake similar to the situation in the Arrow lakes, since this large oligotrophic lake has a limited drainage basin. In contrast to lakes downstream with a flushing rate of one year, Okanagan Lake flushes itself every 58 years [Canada-British Columbia Okanagan-Agreement (CBCOA) 1974], therefore, the retention rate of potential contaminants in the system is much greater. The lake is controlled by a small dam that alters water level to a maximum of 1.3 m. As the lake is well studied (*see* reports of CBCOA, available from the British Columbia Water Resources Service, Parliament Buildings in Victoria, British Columbia).

During 1988, *R. falcatus* was captured at a site indicated in previous records, namely the lake shore opposite Kelowna. The species was not found in the northern portion of the lake. Except for one specimen found in a non-weedy area, the species was captured in shallow water over a stoney bottom where a band of water reed (*Scirpus acutus* Muhl.) occurred at depths greater than one meter offshore. This shallow area between the shore and *Scirpus* was washed by waves and had no sediment; the latter apparently settling in deeper water near the beds of *Scirpus*. Most of the shoreline of Okanagan Lake does not have this habitat and new development around Kelowna is destroying such areas. In particular, there is a tendency for shoreline property owners to bulldoze the beach line to push stones out of the way so as to create a sandy bathing beach.

Okanagan Lake temperatures in August probably reach near the maximum preferred by *R. falcatus*. Effects of temperature variation in inshore habitats must yet be determined. Extensive beds of *Scirpus* occur near Penticton, but whether associated stoney habitat or other requisites occur there is not known; more sampling is needed.

Fraser River Habitat

The only habitat in the Fraser River drainage where I looked for and captured *R. falcatus* is between Chilliwack and Hope (large numbers found at Herrling Island). Environmental consultants have indicated to me that they also encountered the species in numbers in the same area as did Gee and Northcote (1963). The habitat is of further significance in that it may approach conditions of large river habitats found in the Columbia River before the myriad of dams and reservoirs were constructed. In contrast, Fraser drainages could be expected to have cooler temperatures and shorter periods of warming because of their northern latitude.

We did not locate water level data in time for this report, however casual observation suggests May and June are the periods of peak flooding from snow melt, with fall and winter being periods of low water. There could be minor fluctuation of water level on the coast due to fall and winter precipitation which falls as rain on the coast but as snow in the interior. Immense gravel bars are exposed where the river spreads out below Hope to flow toward the Fraser Delta. These expansive bars become islands with small river channels separating them at low water. Because the species inhabits shorelines of one meter depth (Gee and Northcote 1963), *Rhinichthys falcatus* would have to shift up and down the banks of the river with the fluctuating water level.

Given the species preference for weaker flow (compared to *R. cataractae* and *R. umatilla*), its dominance where the river widens out is understandable. I would expect there could be pockets of the species in the river between Hope and Williams Lake; Gee and Northcote (1963) found fish upriver at MacAllister. However, the absence of literature records in sections such as the swift flowing and notorious Fraser Canyon is reasonable.

In general, the lower Fraser is much more silt laden than other localities whose habitat is described here. The cycle of spring floods with shifting currents washes away excessive silt that might have accumulated on stones, thus providing some shelter for the species.

Conclusions on Habitat
Habitats in the Fraser River are not in critical condition for *R. falcatus* as a whole, although there could be problems in localized areas. Columbia River habitats are more vulnerable, with the Kootenay and Arrow lakes populations vulnerable due to dam construction. The Similkameen population is sparsely distributed in Canada, although this could be a natural situation with the main reservoir of the gene pool across the border in Washington State. The Okanagan Lake population is also of low density and should be monitored in relationship to potential eutrophication of the habitat from towns such as Kelowna. I believe the Kootenay and Similkameen populations are most deserving of protection because of the sympatry with *R. umatilla* which provides a test for species interactions between closely related populations.

This report hinges on the assumption that *R. falcatus* tends to live in the upper meter of shoreline. On the other hand, lakes with clear water such as Okanagan Lake could also have algal production in deeper depths supporting the invertebrates on which this dace feeds. In areas such as the Okanagan Bridge causeway where algae on rocks near the surface are too thick and smother habitat, there could be optimal conditions where reduced light penetration produces less algae. *Rhinichthys falcatus* might seek cooler temperature at this depth in this warm lake. Small sized *Rhinichthys* are most easily captured in shallow water and are thus more likely to be recorded in shallow habitat. Effort is needed to confirm depth preferences, especially in unusual situations such as in Okanagan Lake.

General Biology

Reproduction and Growth: Gee and Northcote (1963) provide the only data on reproduction that we are aware of. The largest individual in their sample was 119 mm fork length. Carl et al. (1959) as well as Gee and Northcote (1963) report breeding males to have orange-red colouration on the lips and base of pelvic fins. The latter authors report the colour at all seasons. I have observed this colour on *R. umatilla* and *R. osculus* (which have it at the base of the pectoral fins as well), but believe the colouration to be most pronounced in the summer. In contrast to the other species, *R. falcatus* develops tubercles on the top of the head, body, and top surface of the pectoral rays. The body tubercles occur near the distal margin of each scale causing the tubercles to appear to be in rows. My impression is that these tubercles are less conspicuous in fall samples.

Northcote and Gee (1963) concluded that *R. falcatus* in the lower Fraser River spawn in early July, and that their young probably hatch in late July or early August.

I have no information on fecundity; however, I found a high ratio of younger fish in samples from the Similkameen and Kootenay rivers and Arrow lakes and this suggests adequate reproduction. Okanagan samples are inconclusive. In each case, more effort is needed to locate concentrations of mature adults.

Species Movement: There is little information on movements or migration. Gee and Northcote (1963) showed in the field and experimentally that *R. falcatus* prefers flow of less than 0.5 m/sec. They also showed that young fish preferred depths less than 0.3 m whereas seine caught adults were found at depths of between 0.3 and 1 m during daytime sampling. This relationship was reversed at night. Obviously there will be movements to different parts of the river when river levels fluctuate if this relationship is maintained.

Behaviour/Adaptability: Northcote and Gee (1963) indicate that *R. falcatus* in the lower Fraser River fed largely on aquatic insects at age classes 0 and I, but switched to terrestrial insects at larger sizes. In June and July, adult fish consumed primarily *Lumbricus* when water levels were high and fish could have foraged over flooded shorelines.

There is inadequate knowledge of adaptability of *R. falcatus* to change or human disturbance. The populations in Arrow Lakes, the Kootenay River, and Okanagan Lake are being severely tested by man-caused environmental change, and these populations should be monitored.

Limiting Factors

Without adequate data on abundance before reservoir impoundment, it is difficult to compare the status of *R. falcatus* before or after environmental change. The species appears to be adapted to river environments of weak current (< 0.5 m/sec.), stoney bottoms often with some silting, and August water temperatures between 15° and 18°C. The warm 20°C water of Okanagan Lake is an exception; however, temperature tolerances for the species in Washington must yet be compared. I believe hydro dams of the Columbia have had the greatest impact on the distribution of *R. falcatus*, although nutrient enrichment causing excessive algal growth could be a factor in some American waters (and possibly the Okanagan in future years). Competition with other dace may be a factor with sympatric *R.*

umatilla possibly narrowing available niche or habitat in some areas.

Special Significance of the Species

Rhinichthys falcatus is a little-studied species deserving recognition as part of the Columbia River and Fraser River fauna. Its status as a species distinct from other dace in British Columbia was clearly established by Peden and Hughes (1988). As with most of our native fish species, there is little public interest. As a unique species evolving in the Columbia Basin in sympatry with two or three other species of *Rhinichthys*, its partitioning of resources and interactions with these species should be of interest to scientist and naturalist. There have been no studies to determine genetic variation of populations from different river drainages.

Evaluation

In general, *Rhinichthys falcatus* is not a threatened species and should not be placed in any COSEWIC category at the species level. Individual populations in the Columbia system are vulnerable and require protection at the local level. Reservoir construction, and possibly nutrient loading (i.e., Okanagan Lake) are amongst the chief potential threats to the species. In the case of the Okanagan area, warm waters above 20°C could be limiting, and conditions causing excessive warming might be monitored although these are probably more important to the south, in the United States.

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Status of the False Killer Whale, *Pseudorca crassidens*, in Canada*

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Stacey, Pam J., and Robin W. Baird. 1991. Status of the False Killer Whale, *Pseudorca crassidens*, in Canada. Canadian Field-Naturalist 105(2): 189–197.

The False Killer Whale, *Pseudorca crassidens*, occurs at the northern limit of its range and is rare in Canadian waters. There are 23 confirmed records, totalling 10 occurrences from British Columbia, but none are reported from the east coast of Canada. General biology, world-wide status and management are reviewed. Little information is available on stocks or population estimates, but the species is not uncommon world-wide. The False Killer Whale is taken in small numbers in whaling and incidentally in fisheries. Strandings occur frequently and may significantly affect the levels of local populations. The effects of long-term degradation of its environment and subsequent impact on its populations are potentially serious and should be monitored.

Le Pseudorque, *Pseudorca crassidens*, est rare dans les eaux canadiennes, la limite septentrionale de son aire de répartition. Il existe 23 rapports confirmés d'observation, dont dix provenant de la Colombie-Britannique, mais la présence de cette espèce n'a pas été signalée dans l'est du Canada. Ce document parte sur sa biologie générale, son statut et sa gestion à l'échelle internationale. Malgré le manque de données sur la taille des stocks ou des populations, on sait que le Pseudorque est assez répendu dans le monde. Il n'est capturé qu'en petit nombre à l'occasion de chasses à la baleine ou accidentellement dans les pêcheries. Cet animal s'échoue fréquemment, et ce phénomène pourrait contribuer au déclin des population locales. Les effets de la dégradation à long terme de son environnement et les répercussions sur ses populations pourraient être graves et doivent faire l'objet d'une surveillance.

Key Words: False Killer Whale, Pseudorque, *Pseudorca crassidens*, Canada, status, cetacean, North Pacific.

Relatively little is known about the general biology or world-wide status of the False Killer Whale, *Pseudorca crassidens* (Owen 1846), especially in comparison to a variety of larger commercially valuable cetaceans [eg. Humpback Whale, *Megaptera novaeangliae*, and Right Whale, *Eubalaena glacialis* (Gaskin 1987; Whitehead 1987)] or to several relatively accessible species of coastal odontocetes [eg. Killer Whale, *Orcinus orca*, and Bottlenose Dolphin, *Tursiops truncatus* (Shane et al. 1986; Bigg et al. 1987)]. This paper reviews the current state of knowledge of this species world-wide, with special reference to its status and management in Canada. As much of the information on False Killer Whales is anecdotal and widely scattered throughout the published literature, we attempt to review and summarize as many relevant references as possible.

False Killer Whales are toothed whales that attain maximum recorded lengths of 6.1 m for males and 5.06 m for females (Leatherwood and Reeves 1983; Perrin and Reilly 1984). They are slender in build and slightly compressed laterally anterior to the dorsal fin, becoming progressively more compressed caudally (Reinhardt 1866; Ross 1984). The head is rounded and relatively small, with no demarcation between the head and beak (Leatherwood et al. 1982; Figure 1). The dorsal fin is tall, falcate, and positioned slightly behind the midpoint of the back (Leatherwood et al. 1982; Figure 2). A broad hump on the anterior edge of the pectoral flipper near the middle is diagnostic for the species (Leatherwood et al. 1982). The body colour ranges from dark gray to black with a blaze of light gray on the ventral surface between the flippers and occasionally an area of light grey on the sides of the head (Fraser 1936; Tomilin 1957; Leatherwood and Reeves 1983). In males the tip of the upper jaw overhangs that of the lower jaw (Mead 1975). There are typically 8 to 10 large conical teeth in each jaw (Reinhardt 1866; Fraser 1936). Maximum weight is at least 1360 kg (Leatherwood et al. 1982).

Distribution

False Killer Whales are generally confined to tropical and temperate waters throughout the world, although they occasionally stray to higher latitudes (Purves and Pilleri 1978). In the eastern Pacific they have been reported along coastlines from Alaska to the Galapagos Islands and Peru, and from the Hawaiian Islands (Mitchell 1965; Leatherwood et al. 1982; Tomich 1986; Baird et al. 1989). In the western Pacific they have been reported from Japan and the South and East China Seas, to Australia, Tasmania and New Zealand

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FIGURE 1. False Killer Whale stranded alive at Ucluelet, B.C. 28 July 1987. Photo by Mark Hobson.

(Flower 1865; Hershkovitz 1966; Leatherwood and Reeves 1983). In the western Atlantic they have been reported from North Carolina south to the Strait of Magellan (Miller 1920; Brimley 1937; Hershkovitz 1966; Caldwell et al. 1971; CETAP 1982; Goodall and Schiavini 1989). In the eastern Atlantic they have been reported from Britain, Denmark, Holland, and the North Sea south to Portugal and South Africa (Reinhardt 1866; Fraser 1936). False Killer Whales are also found throughout the Indian Ocean and the Mediterranean (Mitchell 1975a; Leatherwood et al. *in press*).

Off British Columbia, their presence has been confirmed by 23 records, all since 1987, and all of single individuals (Table 1; Figure 3; Baird et al. 1989). Three of these records represent strandings. Fourteen of the records were sightings in Barkley Sound on the west coast of Vancouver Island in 1989 and were most likely of the same individual (Barry et al. 1989). There have been several other reports of a single False Killer Whale in Barkley Sound, but details are insufficient to positively confirm species identity. There is one record from Prince William Sound, Alaska (Martin *in* Leatherwood et al. 1982), and two records from Washington State (Scheffer and Slipp 1948; Osborne et al. 1988). There are no confirmed records from the east coast of Canada. A record cited by some authors from Davis Strait, off Baffin Island, is unsubstantiated (Miller 1920). The scarcity of records in Canada and the increasing frequency of records progressively southward suggest that False Killer Whales are at the northernmost limit of their range in Canadian waters.

Protection

International

Regulation of international trade between members and non-members of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) has been established by listing the False Killer Whale under Appendix II of the Convention (*see* Birnie 1982). The International Whaling Commission (IWC) regulates the taking of whales in accordance with the current Schedule provisions, but whether this Commission's mandate covers the False Killer Whale is unclear, as members of the Commission are divided as to whether "whale" refers to all cetaceans, or only to some species (Klinowska 1987).

National

Canada: The 1982 Cetacean Protection Regulations of the Fisheries Act of Canada of 1867 (as amended to date) provide protection for this and other species of cetaceans from all but aboriginal hunting. "Hunting" is defined as "to chase, shoot at, harpoon, take, kill, attempt to take or kill, or to harass cetaceans in any manner", and can only be undertaken under licence.

FIGURE 2. False Killer Whales in Puget Sound, Washington, May 1987. Photo by John Calambokidis.

United States: In the United States all cetaceans are protected under the Marine Mammal Protection Act of 1972, as well as under the Packwood-Magnuson Amendment of the Fisheries and Conservation Act and the Pelly Amendment of the Fisherman's Protective Act.

Population Sizes and Trends

No estimates of numbers exist. Ross (1984) notes that the possible existence of morphologically distinct populations has not been established, owing to a lack of knowledge of the expected degree of variation within a population. Purves and Pilleri (1978) examined skeletons from 99 individuals from a single stranding in the British Isles, and noted a large proportion of atavistic characters. They concluded that the latter were of genetic origin and gave support to the notion that whole schools could be closely related or possibly even a single family. Off Japan, the gross annual reproductive rate was calculated at 5% to 6% (Kasuya 1985), close to the mortality rate of some well-analyzed delphinids, suggesting that populations may not be increasing (Kasuya and Marsh 1984).

The numbers of animals in schools that have stranded are normally very large, ranging from 50 to 835 animals (mean of 180, n = 14) [Ross 1984]. The size of schools observed at sea is typically small, usually fewer than 20 to 50 animals (Ross 1984), leading some researchers to suggest that when a mass stranding occurs, several schools have joined together for some reason (Ross 1984). Some larger herds with numbers estimated between 600 and 700 individuals have been seen in the eastern tropical Pacific (Miller and Odell *in press*). From 157 sightings in the eastern tropical Pacific of fewer than 100 animals, mean group size was 18 individuals, with a range of 1 to 89 (Miller and Odell *in press*). Tomilin (1957) suggests that judging by the size of the stranded schools, False Killer Whales are a species of considerable abundance.

Ross (1984) suggests that because False Killer Whales are conspicuous at sea and will often approach boats, sight records could be a fairly good estimator of actual population distributions and densities. However, considering the lack of experienced observers and comprehensive sighting surveys, and the difficulties in distinguishing between False Killer Whales and similar-appearing species such as Pilot Whales (*Globicephala* sp.), it is probable that False Killer Whales are more common than reported.

It appears that False Killer Whales are at the limit of their distribution in Canadian waters and therefore have always been rare. Present population trends are unknown due to the scarcity

TABLE 1. False Killer Whale records from Canada. All records are of single individuals.

Date	Location	Type[a]	Source[b]
03 May 1987	49°27′N, 124°41′W	1	1
22 June 1987	50°35′N, 126°52′W	2	1
28 July 1987	48°58′N, 125°33′W	3	1
06 June 1988	50°34′N, 126°50′W	2	2
08 July 1988	48°57′N, 125°19′W	2	2
21 July 1988	48°59′N, 125°19′W	2	2
29 September 1988	48°59′N, 125°19′W	2	2
16 April 1989[c]	49°00′N, 125°00′W	2	2
21 June 1989[c]	48°57′N, 125°05′W	2	2
30 June 1989[c]	48°54′N, 125°06′W	2	2
20 July 1989[c]	48°57′N, 125°02′W	2	2
22 July 1989[c]	48°59′N, 124°59′W	2	2
28 July 1989[c]	49°00′N, 125°03′W	2	3
29 July 1989[c]	49°00′N, 125°03′W	2	3
01 August 1989[c]	49°00′N, 125°03′W	2	3
05 August 1989[c]	48°57′N, 125°05′W	2	2
03 September 1989[c]	49°04′N, 124°52′W	2	2
04 September 1989[c]	49°04′N, 124°52′W	2	2
09 September 1989	49°15′N, 126°05′W	2	2
16 September 1989[c]	49°04′N, 124°52′W	2	2
17 September 1989[c]	49°04′N, 124°52′W	2	2
30 September 1989	49°10′N, 126°00′W	4	4
17 October 1989[c]	49°00′N, 125°00′W	2	2

[a]Type: 1. Stranding, dead; 2. Sighting; 3. Live stranding, returned to water; 4. Live stranding, died.
[b]Source: 1. Baird et al. 1989; 2. British Columbia Marine Mammal Sighting Program Stacey and Baird, unpublished data; 3. Barry et al. 1989; 4. Langelier et al. 1990.
[c]These records are likely repeat sightings of the same individual seen in the same general area.

of reported sightings and lack of distributional surveys.

Habitat

False Killer Whales are found most often offshore, although there are occasional records from inshore waters (Fraser 1936; Scheffer and Slipp 1948; Tomilin 1957; Lindsay 1964; Osborne et al. 1988; Baird et al. 1989). They are reported to frequent waters deeper than 30 fathoms in the northeastern Gulf of Mexico (Brown et al. 1966). Little information is available on the water temperatures of the False Killer Whale's habitat. They frequent both tropical and temperate waters with a wide range of temperatures. Sea surface temperatures at the time of the British Columbia records ranged from 9°C to > 20°C (Baird et al. *unpublished data*). The offshore habitat of the False Killer Whale is generally less susceptible to human impact and degradation than are coastal areas.

General Biology

Reproduction

Information on reproduction has largely been gained from analysis of specimens obtained from strandings or from fisheries data. The sex ratio is approximately equal in stranded schools (Ross 1984). As False Killer Whales are sexually dimorphic, and thus presumably polygynous (Ralls 1977; Connor and Norris 1982), male parental investment is expected to be relatively low (Marsh and Kasuya 1986). Age of sexual maturity in both sexes has been estimated by Purves and Pilleri (1978) to be between eight and 14 years at body lengths of 3.6 m or more in females (Tomilin 1957; Purves and Pilleri 1978). Estimates of the length of calving seasons range from several months to year-round (Ross 1984; Miller and Odell *in press*). Estimates of gestation range from 15.5 to 15.7 months (Purves and Pilleri 1978; Kasuya 1985). Length at birth ranges from about 1.5 m to 2.1 m (Leatherwood et al. 1976). Lactation has been estimated to last between 18 months and two years (Purves and Pilleri 1978; Perrin and Reilly 1984).

Longevity has not been determined. However, several of the oldest individuals reported have had up to 26 growth layer groups in the dentine (Purves and Pilleri 1978; Baird et al. 1989). In these cases the pulp cavities of the teeth were completely occluded, restricting further dentine deposition and making maximum age determination using this technique impossible. Marsh and Kasuya (1986) recorded individuals greater than 41 years of age, taken in the Japanese drive fishery, using

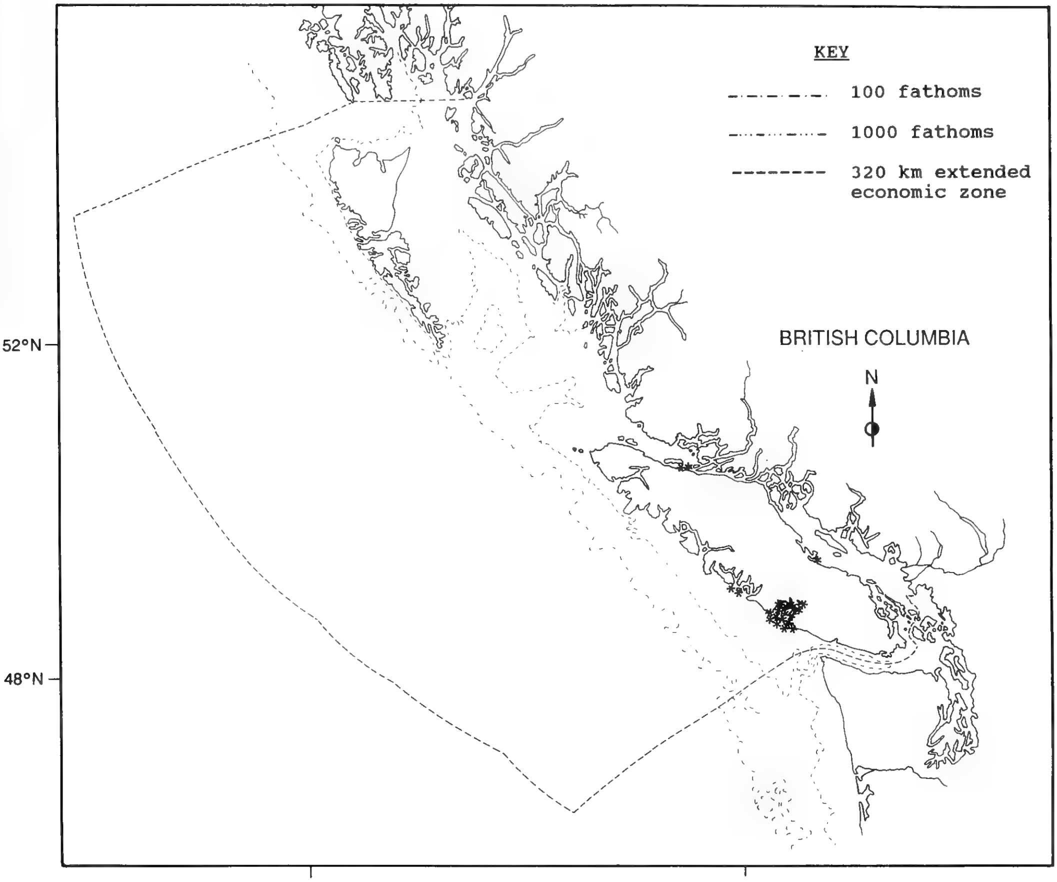

FIGURE 3. Known records of the False Killer Whale in Canada. See Table 1 for details of records. There are no records off the Canadian east coast.

growth layer groups in the cementum to age them. None of the 12 females greater than 41 years of age were pregnant, suggesting that reproductive senescence may occur in this species.

False Killer Whales are held in several aquaria around the world and have bred in captivity, producing both pure bred animals and hybrids with Bottlenose Dolphins (Nishiwaki and Tobayama 1982; Leatherwood et al. 1989).

Species Movement

Miller and Odell (*in press*) report that migrations have not been documented. Tomilin (1957) suggests that inshore movements are occasionally associated with those of squid. He also reported a school of False Killer Whales that followed a ship from Brazil to the English Channel. If such movements do occur, it is unlikely that distinct stocks within particular ocean basins exist.

Behaviour

False Killer Whales frequently strand in large numbers (Caldwell et al. 1970; Odell et al. 1980; Nicol 1986). High sociability is suggested by the large numbers and mixed age and sex classes found in strandings (Sergeant 1982). Strong social bonds are also evident, as in the description of a False Killer Whale stranding by Porter (1977) where a large injured male was supported for three days by 15 others in a shallow bay, until he died. Food sharing in the wild has also been observed (Connor and Norris 1982).

In captivity False Killer Whales are more easily tamed and trained than many other species of cetaceans, and are extremely adept at learning by observation (Brown et al. 1966). Research on False Killer Whale acoustical behaviour has been conducted on animals in captivity (Mizue et al. 1969; Kamminga and van Velden 1987; Thomas et al. 1988).

Only anecdotal observations have been reported of the reactions of False Killer Whales to vessels. False Killer Whales will often approach and ride the bow- or stern-waves of boats, the only "blackfish" to regularly do so (Brown et al. 1966; Leatherwood et al. 1976; Ross 1984). In the Gulf of Mexico, False Killer Whales have been reported to be wary of boats (Brown et al. 1966).

False Killer Whales appear to be opportunistic feeders, consuming a large size range and wide variety of prey, including the squids *Oregoniateuthis* sp., *Todarodes* sp., and *Phasmatopsis* sp., and fish species such as Bonito (*Sarda* sp.,), Mahimahi (*Coryphaena hippurus*), Yellowtail (*Pseudosciaena* spp.), Perch (*Lateolabrax japonicus*), Salmon (*Oncorhynchus* sp.), and mackerel (Scombridae) [Tsutsumi et al. 1961; Brown et al. 1966; Connor and Norris 1982; Ross 1984; Kasuya 1985; Baird et al. 1989]. In the eastern tropical Pacific they have been reported preying on smaller dolphins (*Stenella* spp. and *Delphinus delphis*) (Perryman and Foster 1980). These observations were made both while the smaller dolphins were free swimming prior to their capture in tuna purse-seine nets and during their release. According to Hoyt (1983) there is at least one record of predation on a Humpback Whale calf.

Some speculation exists as to whether the numerous tooth rakes observed on Humpback Whales can be attributed entirely to Killer Whales. Fales Killer Whales are more abundant than Killer Whales in the Humpback's Hawaiian wintering grounds (Tomich 1986) and may be responsible for some of the attacks. Apparently, non-aggressive interspecific associations are rare, but Tsutsumi et al. (1961) have noted that associations with Bottlenose Dolphins occur during the winter off Japan. Sergeant (1969) calculated a mean daily feeding rate of a captive animal as 4.7% of the total body weight.

Limiting Factors

Perceived conflicts with fisheries have resulted in deliberate killing of this species in some areas. False Killer Whales have been recorded stealing hooked fish in the Japanese tuna long-line fishery and in the Gulf of Mexico (Brown et al. 1966; Mizue et al. 1969). In the Iki Island area of Japan they are killed to reduce conflicts with fisheries (Kasuya and Izumizawa 1981; Kasuya 1985). They are also taken occasionally in the small whale fishery in St. Vincent, in the Caribbean (Caldwell et al. 1971; Caldwell and Caldwell 1975). False Killer Whales have been taken incidentally in the gill-net fishery in northern Australian waters, the tuna purse-seine fishery in the eastern tropical Pacific, Chinese fisheries, and in Sri Lankan waters (Bannister 1977; Perrin and Oliver 1982; Zhou et al. 1982; Harwood et al. 1984; International Whaling Commission 1986; Leatherwood et al. *in press*). Small numbers have been taken for live display (Bannister 1977; Reeves and Leatherwood 1984; International Whaling Commission 1984, 1987).

Causes and rates of natural mortality are largely unknown although mass strandings may significantly affect the level of local populations (Mitchell 1975a). Parasitic infestation of the inner ear by the trematode *Nasitrema gondo* has been implicated as a cause of mass stranding in False Killer Whales off Japan (Morimitsu et al. 1987). A variety of other parasites have been identified in False Killer Whales, including the trematode *Orthosplanchus elongatus*, the nematodes *Anisakis simplex, Sternus auditivus*, and *Sternus globicephalus*, and the acanthocephalan *Bolbosoma capitatum* (Zam et al. 1971; Odell et al. 1979), although they have not been shown to cause mortality under normal conditions. No documented cases of predation by Killer Whales or sharks have been reported.

The introduction of toxic substances into the marine environment has as yet undetermined consequences. However, though bioaccumulation in the food chain, organisms such as the False Killer Whale may accumulate high levels of different toxins, even though they are an offshore species and thus presumably have low exposure to high levels of chlorinated hydrocarbons (Gaskin 1985). Tissue samples from a stranded False Killer Whale in British Columbia revealed the highest levels of mercury yet reported from a cetacean (liver, 1614 ppm wet weight), as well as high DDE levels in another individual (blubber, 1400 ppm wet weight) [Baird et al. 1989; Langelier et al. 1990]. High levels of organochlorines have been implicated in immunosuppression and high mortality in the St. Lawrence population of Belugas, *Delphinapterus leucas* (Martineau et al. 1987). The effects of other industrial activities on large odontocetes, such as oil and gas development and shipping, are largely unknown but warrant further study (Hain et al. 1985).

Special Significance of the Species

Many populations of dolphins and small whales are exploited directly or incidentally and must be assessed and managed (Perrin and Reilly 1984). False Killer Whales and other small cetaceans have generally received little attention and concern compared with the larger commercially harvested species. However, due to the frequency of, and numbers involved in mass strandings in certain areas of the world, False Killer Whales have become well known to local human populations. Their presence in aquaria around the world has brought increased attention and interest to them and other small cetaceans.

While regulation of fisheries for large cetaceans is under at least some level of control and management, regulation and management for small cetaceans is virtually non-existent worldwide. The deaths of over 600 Bottlenose Dolphins off the United States east coast in 1987 and 1988 (Marine Mammal Commission 1989) have helped to bring the increasingly complex factors affecting small cetacean populations into the forefront.

Evaluation

Occasional catches incidental to small whale fisheries will probably continue as long as these are in operation (Mitchell 1975a). However, the level of exploitation has probably not had a significant impact on stocks (Mitchell 1975b). There is no evidence that this species is or ever was common in Canadian waters. Based on the small amount of data available it is impossible to determine population trends. The False Killer Whale is rare in Canadian waters, as it is in the northernmost limits of its range, but its continued existence here does not appear to be under any threat and should not be considered at risk in Canadian waters.

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An Update on the Status of the Right Whale, *Eubalaena glacialis*, in Canada*

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Gaskin, David E. 1991. An update on the status of the Right Whale, *Eubalaena glacialis*, in Canada. Canadian Field-Naturalist 105(2): 198–205.

Information on the North Atlantic Right Whale, *Eubalaena glacialis*, accumulated since the previous COSEWIC report, prepared in late 1983, is summarized. The Bay of Fundy approaches still seem to be the most important summer ground for mothers with newborn calves. An analysis of historical data suggests that no comparable calving area existed on the west coast of Canada. The wintering areas for the majority of the eastern seaboard population remain unknown, although a significant concentration of mothers with calves has been found on the coastal shelf off Georgia. Photo-identification methods confirm a minimum population of about 207 animals on this coast. The recently published suggestion that Right Whales may have been rare on the east coast since the 1600s is discussed in the context of relatively new data about the Basque whale fisheries off Newfoundland and Labrador from the 1500s onwards. The known life cycle parameters are summarized; the balance of evidence now points to a reproductive cycle with a mean duration of three years, and a gestation period of perhaps 13 to 14 months. The information now available shows that up to 35% of the east coast animals bear scars of impacts or entanglements with fishing gear, especially gill nets; most confirmed deaths by accident are still the result of ship strikes. An increase in the size of this population remains unconfirmed.

Ce rapport résume les informations recueillies sur la Baleine noire (*Eubalaena glacialis*) de l'Atlantique Nord depuis le rapport précédent du CSEMDC datant de la fin de 1983. Les approches de la baie de Fùndy semblent encore constituer une aire d'estivage de première importance pour les femelles et leurs nouveau-nés . D'après une analyse des données chronologiques, il n'existe pas d'aire comparable de mise bas sur la côte ouest du Canada. On ne connaît pas encore les aires d'hivernage de la majorité de la population de la côte est, bien qu'une concentration importante de femelles accompagnées de leurs baleineaux ait été observée sur la plate-forme continentale au large de la Géorgie. Les méthodes d'identification par photographie ont permis de confirmer la présence, sur cette côte, d'une population comptant au minimum 207 individus. L'hypothese, récemnent publiée, selon laquel la Baleine noire serait rare sur la côte est depuis le 17e siècle, est examinée à la lumière de données relativement nouvelles sur la chasse à la baleine par les Basques au large de Terre-Neuve et du Labrador à partir du 16e siècle. Le rapport résume aussi les paramètres connus du cycle vital; les connaissances actuelles indiquent l'existence d'un cycle de reproduction d'une durée moyenne de trois ans et d'une gestation qui s'étend peut-être sur 13 à 14 mois. Ces données montrent, en plus, que l'on compte jusqu'à 35% des animaux de la côte est portant des cicatrices de blessures causées par des chocs ou des empêtrements avec les engins de pêche, surtout les filets maillants; la plupart des cas confirmés de mortalité par accident sont le résultat de collisions avec des navires. On n'a pas encore confirmé d'accroissement démographique.

Key Words: Baleen Whale, Right Whale, Baleine noire, *Eubalaena glacialis*, endangered, whaling.

The Right Whale, *Eubalaena glacialis* (Müller 1776), occurs in two geographically segregated populations in the North Pacific and North Atlantic, both of which in turn may be subdivided to a greater or lesser extent into eastern and western "stocks". The southern hemisphere population is conveniently regarded as a separate subspecies. Population genetic studies based on DNA comparisons are currently in progress (R. Payne, J. Perkins, C. N. Schaeff, and B. N. White, unpublished data); it is hoped that these will permit the taxal distance between the North Atlantic and South Atlantic populations to be resolved. The three major groupings were all reduced to relict status by commercial whaling between the 15th to 19th centuries. Right Whales generally occur in lower temperate and upper subtropical latitudes in the winter months and migrate into productive, relatively cool higher temperate waters in summer.

The status of the Right Whale in Canadian waters was earlier reviewed by Hay (1985) and Gaskin (1987); the latter was based on published information and research in progress until late 1983. Here the results of research carried out since then are summarized and the many problems which remain are discussed.

*Report accepted by COSEWIC 11 April 1990 — no change in status designation. Endangered status originally assigned by COSEWIC April 1980 (Hay 1985; *see also* Gaskin 1987).

Distribution

North Pacific: The surviving North Pacific population is estimated to be in the low hundreds (Ohsumi and Wada 1974). There are no comprehensive census data from the 1980s. Most of the remaining animals appear to congregate in summer around the eastern Aleutian Islands and Kodiak Island and the adjacent waters of the southeastern Bering Sea. The winter range is extensive, and poorly known. No coastal concentrations have been recorded in this century. If there ever was a distinct sub-population around Japan it is probably virtually extinct. Some Right Whales were reported from the Sea of Okhotsk by Klumov (1962). There appear to have been no sightings of this species on the west coast of Canada in the present decade. I am aware of only one recent sighting on the entire western seaboard south of Alaska, off the coast of southern California (Johnson 1982). Braham (1986) published a bibliography on Right Whales in the eastern North Pacific, with documentation of sources and useful summaries of each article. Annotated surveys of catch records from Japan (Omura 1986), from Alaska (Brueggeman et al. 1986) where 20 Right Whales were taken by two whaling stations operating from 1917 to 1939, and from the entire North Pacific south of 50° N during the 19th and 20th centuries (Scarff 1986) are useful additions to the literature on this species. Although Scarff (1986) confirmed a total pelagic catch of 19 200 during the 19th century, neither pelagic nor coastal whaling station records give an indication that the Right Whale was ever particularly common on the western seaboard of North America. Nor is there evidence that Right Whales came to this coast for calving (Scarff 1986). Although a Right Whale has been recorded several times in Hawaiian waters in recent years, the whaling records do not suggest that this archipelago was ever a significant calving ground. One may speculate that North Pacific Right Whales were adapted to mating, raising and feeding calves over deep water. There may never have been discrete coastal calving zones in this ocean, which would certainly explain why so many vessels searched but failed to find one. They may calve in the gyre regions of the northern subtropical and low latitudes of the North Pacific temperate belt.

Right Whales are sighted in summer months in several parts of the Bering Sea (Klumov 1962; Nemoto 1957), but always in small numbers, with no evidence in the sighting trends for significant recovery (*see* summary maps in Gaskin (1976, 1982) for the basic distribution pattern).

North Atlantic: the distribution and movements of the North Atlantic Right Whale have been intensively studied since 1980 and are reasonably well known. The population is dispersed in winter; some animals are on the coastal shelf off Georgia and Florida, but the whereabouts of at least half the population has not yet been determined. Rarely animals are seen as far as out as Bermuda. Scores of Right Whales gather in the Cape Cod Bay and Great South Channel regions in April. In early summer they are on the move again, and the population disperses northwards. Significant concentrations spend the summer and early fall in the vicinity of Brown's Bank off Nova Scotia and in the lower Bay of Fundy. Scattered sightings in recent years have been made again in the Gulf of St. Lawrence and off Newfoundland. In pre-whaling days, and in the days of Basque whaling, the range extended to southern Greenland and southern Davis Strait. Today, however, the only significant summer grounds in Canadian waters for this species are off New Brunswick and Nova Scotia.

Recent data have been presented by Kraus (1985), Kraus et al. (1986), and Mead (1986). Mitchell et al. (1986) provided a thorough analysis of the sighting records from Canadian whaling vessels off Nova Scotia in 1969 to 1972. None of these data significantly change the basic patterns of distribution published previously (*see* Gaskin 1987 for a review). In the last few years attempts have been made to find out more about the winter distributions of the population in the North Atlantic. Aerial surveys in 1984 and 1985 found about fifteen animals including six cow-calf pairs, on the coastal shelf between Jekyll Island and Amelia Island off the coast of Georgia (Kraus et al. 1986). These sightings represent less than 5 to 15% of the animals estimated to be somewhere off the eastern seaboard during the winter, suggesting that they are so scattered between November and March that it is not possible to locate them, especially in the poor weather conditions characteristic of these months. Alternatively, some of the population may not necessarily move south in the fall months; many may winter offshore in areas where secondary productivity is still relatively high. It might be worthwhile to direct search effort along the northern margin of the Gulf Stream water between the Carolinas and central Nova Scotia.

Protection

The Right Whale remains theoretically safe from hunting because of its Protected Stock status under the International Whaling Commission (IWC). This still leaves it vulnerable to capture by non-signatory nations; Brazil and Chile each killed at least six between 1950 and 1975 prior to their joining the IWC, and even Canada took one "by

accident" in the 1950s. The species remains listed on Appendix I of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), but this only covers trade in products from the Right Whale and does not actually convey any specific protection against killing *per se*. The taking of Right Whales in waters under Canadian jurisdiction is strictly prohibited under the Canadian Whaling Regulations, promulgated under the authority of the the Fisheries Act.

Population Sizes and Trends

A review of the status of the world populations of Right Whales in 1983 was published by the International Whaling Commission (IWC 1986) with some revisions and updates. Little fresh information has been published in the last two years. In the eastern and western North Pacific, Ohsumi and Wada (1974), and Wada (1976), gave population estimates, based on factory ship expedition sightings, of 120 and 134 respectively, with no evidence of increase. As indicated previously (Winn 1982; Kraus 1985; Gaskin 1987), the best census estimate for the western North Atlantic obtainable from the Cetacean and Sea Turtle Program (CeTAP) aerial survey data, corrected for dive times, is still 380 ± 688. Application of mark-recapture methods to the recognizable animals in the CeTAP data yielded an estimate of 200 ± 100 individuals (Kraus 1985). Photo-identification studies have the potential to provide much more accurate estimates and the results show considerable promise; with application of rigorous analytical techniques (Kraus 1985; Kraus et al. 1986), the number of verified animals in this population has increased from 85 to 207 (Kraus et al. 1986). The dwindling number of animals, other than calves, being added to the catalogue in recent years suggests that 207 may not be far from the asymptotic value for this population.

A particularly interesting assessment of historical records for Right Whales and whaling on the coast of Massachusetts was published by Schevill et al. (1986). As reported previously (Watkins and Schevill 1982; Kraus 1985), Right Whales can be seen in almost any month of the year, but are usually far more abundant in April. This concentration of animals in spring appeared to be related to density of copepod patches (Kenny et al. 1986) and precedes the early summer migration to more northerly waters between the Bay of Fundy and eastern coastal shelf of Nova Scotia. A maximum of 70 individuals was recorded for a single day.

Schevill et al. (1986) compared data gained from studies made from 1955 to 1981 with historical records from 1620 to 1900. the results were unexpected; contrary to the commonly held assumption that whaling in the colonial period had been responsible for drastically reducing the number of Right Whales in this population, Schevill et al. (1986) concluded that the numbers seen each year off Massachusetts in modern times are little different from those in the 1700s to 1800s. Nor could they find any population trends in the data from 1955 to 1981. It is possible that earlier whaling by the Basques was responsible for the reduction of the population, but there is no evidence that the Basque fleets operated much south of eastern Newfoundland. For over-exploitation of Right Whales to have taken place at their hands the bulk of the whale population must have migrated north to eastern Newfoundland and Labrador in summer. This is not the case now. It may be that the Fundy-Browns Bank population represents a deme, never numerous historically, which never went to Newfoundland waters and so escaped the early slaughter. Since the Right Whale appears to require very dense copepod concentrations, it may always have been relatively locally distributed, in the broad geographical sense, within the western North Atlantic, because it was strictly resource-controlled by the restricted availability of such densities. In Cape Cod Bay the copepods concentrate in surface layers; in the Bay of Fundy they concentrate below 100 m.

Archaeological finds made in the last decade or so at Red Bay, Labrador, in the Strait of Belle Isle, suggest that the potential influence of Basque whaling on eastern Bowhead and western North Atlantic Right whale stocks was almost certainly far greater than anyone might have believed even ten years ago. From an analysis of the large deposits of whale bones found in the vicinity of the whaling station, Cumbaa (1986) concluded that the average catch was about 50% ***Balaena mysticetus*** and 50% ***Eubalaena glacialis***. Research suggests that the Basques operated in the Red Bay area almost continuously from about 1530 to the early 1700s, with as many as 20 ships based there each season (Barkham 1984). By 1609, whales were becoming scarcer. Based on estimated efficiency levels of Basques whalers in European waters, 300 to 500 animals could have been taken each year at the peak (Aguilar 1986), but this includes a significant proportion of eastern Bowhead whales. If the proportion was assumed to be about 50%, (i.e., about 200 Right Whales per year) and peak operations lasted for about 70 years (1530 to 1600), with perhaps one third of struck-and-lost-animals dying, then the cumulative catch of ***Eubalaena glacialis*** might have been as high as 21 000 and the initial stock perhaps 12 to 15 000. The almost

complete absence of Right Whales from northern Canadian waters in modern times indicates that the Bay of Fundy — Browns Bank whales are a separate sub-stock which, because they prefer deeper shelf water, partially escaped the full pressures of colonial whaling, and because they remained south of Nova Scotia, were not exploited by the Basques at any time.

Habitat

The general bathymetric and oceanographic features of what appears to be primary habitat for Right Whales in summer and early fall has been described by Winn (1982) and Gaskin (1987). Some trophic considerations were addressed by Kraus (1985). A detailed account of the western Bay of Fundy summer habitat zone, and the changes that occur during the season, is given by Murison and Gaskin (1989). The essential features of the habitat in this region during the period of occupation by Right Whales, based on data collected in 1983 and 1984 and published by Murison and Gaskin (1989) are: a surface temperature range from 10° to 16°C in July-September with means from 12.6° to 13.7°C; a temperature differential between the surface and 50 m of 4.8 to 6.6°C at three selected locations in the Basin area in August; a well-marked thermocline at 20 m in mid-August and between 5 to 20 m in mid-September, but with no marked chemocline; stratified waters in the Basin region but considerable topographic upwelling with cooler temperatures off southeastern Grand Manan and several variable tidal stream fronts at intervals of several km, generally oriented to the long axis of the Bay of Fundy. There is distinct daytime stratification of copepods by size class and depth; 83 to 98% of large (4.0 mm metasomal length) and medium-sized copepods (2.0 to 3.9mm) are below 100 m and 55 to 61% of small specimens (2.0 mm) are between the surface and 50 m. Bathymetric depths over which animals were recorded ranged from about 90 to 240 m.

The general annual distribution of Right Whales on the eastern seaboard was figured by Kraus et al. (1986), and the seasonal patterns which occur in the Bay of Fundy have been outlined by Kraus et al. (1982: Figures 2, 3) and Gaskin (1987: Figures 5-7). Data obtained since these studies do not substantially modify the previous findings, although some statistically significant shifts are recorded from year-to-year. Gaskin (1987) suggested that these changes might be most easily related to movements or breakdown of transition zones between well-mixed and thermally stratified water masses.

Habitat Protection: No protection measures exist for Right Whale habitat on either coast of Canada, or the United States. Although sanctuary areas have been unofficially proposed these do not yet have any status and there are still formidable problems in determining how rigorous the protection needs to be, other than trying to ameliorate the serious problem of whale entanglement in fishing gear. For example, Kraus (1985) reported that 35% of all photo-identified Right Whales in the western North Atlantic bore marks of varying severity which appeared to have been caused by fishing gear, usually by gillnets. The influence of whale-watching does not seem to be modifying Right Whale behaviour or movements in the summer feeding and mating areas (Watkins 1986).

Degree of Specialization and Consequent Vulnerability: The "bottom line" for the western North Atlantic Right Whale appears to be the availability of dense, or moderately dense, concentrations of calanoid copepods (Gaskin 1987; Murison and Gaskin 1989; Winn 1982). Watkins and Schevill (1976, 1979) recorded Right Whales feeding on mixed dense patches of copepods and juvenile euphausiids in the Cape Cod region, although the species does not seem to intensely exploit euphausiids in the Bay of Fundy. Murison (1986) and Murison and Gaskin (1989) noted that the animals which occupy the lower Bay of Fundy in summer and early fall appeared to be leaving while the concentrations of euphausiids were still increasing, but calanoid copepods were clearly decreasing. Collected faecal samples show that *Calanus* parts greatly predominate (Kraus 1985; Murison 1986). This specificity of diet in the North Atlantic population is interesting. Matthews (1932, 1938) noted that the animals off Patagonia and South Georgia ate large zooplankton, but Kawamura (1978) showed that a close correlation existed between the distribution of Right Whales in the southern hemisphere and major concentration areas of *Calanus tonsus* and other species of copepods (*see* summary in Gaskin 1987: 303). More recently, Hamner et al. (1988) confirmed active surface feeding by Right Whales off the Antarctic Peninsula on swarms of *Euphausia superba*, which contradicts the suggestion by Gaskin (1987) that Right Whales might swim too slowly to deal with rapidly swimming euphausiids.

The problems of establishing realistic energy budgets for Right Whale populations have been discussed by Kenney et al. (1986), Hamner et al. (1988) and Murison and Gaskin (1989). At present the estimates of Right Whale requirements appear to range up to three times the available energy based on measured densities of plankton patches in the Cape Cod region. This paradox may relate both to under-estimation of the encounter

frequency with dense patches, and over-estimation of thermal loss in Right Whales. Some clues for solution of this paradox are provided by the recent work of Mayo et al. (1987), who found experimentally that *Calanus finmarchicus* was retained more effectively than other taxa by Right Whale baleen. They also skimmed neustonic samples of zooplankton in a Right Whale feeding path and obtained up to seven times more available biomass per cubic metre than in samples collected by regular techniques that sampled the water column.

Biology

Work during the 1980s has added to our meagre store of knowledge about the biology of Right Whales, but firm data on many aspects are still lacking.

Reproductive Biology: Recent studies still point to the majority of births in the North Atlantic population taking place between December and March. Most births appear to occur in shelf waters off Georgia and Florida although Schevill et al. (1986) recorded two births in or near Cape Cod waters. These events were in March and April, as previously estimated, but further north than most births (Kraus 1985; Kraus et al. 1986).

The length of the breeding cycle was estimated to be a little over three years by Kraus (1985), who estimated 3.12 ± 0.60 (SD) with a range of two to five years. The majority of animals appeared to have a three-year cycle. The actual gestation period remains a matter of dispute. Following Klumov (1962) the majority of biologists had assumed this to be about 12 months, but as Kraus (1985) has pointed out, this concept is difficult to reconcile with observations of mating behaviour from July through early October and a peak of births in February and March. The work of Nerini et al. (1984) on the closely related Bowhead Whale pointed to a gestation period of 13 to 14 months, a figure which is compatible with the sexual behaviour seen each summer in the Bay of Fundy and on Browns Bank which is assumed to lead to conception. It is possible that further activity which leads to conception, compatible with a 11 to 12 month gestation period, takes place elsewhere, but this looks less likely.

Kraus (1985) and Gaskin (1987) summarized recent discussions about the value of the Gross Annual Reproductive Rate (GARR) in this population. The IWC (1986) calculated a theoretical rate for the species in general (based on an estimated birth rate of 0.24 and a sex ratio of 1:1) with a range from 0.07 to 0.092. Kraus pointed out that none of the observational data from either hemisphere supported the existence of a GARR this high and concluded that there had to be a bias either in the input data or in the assumptions about population structure. If the North Atlantic Right Whale population is in the process of rather rapid growth, then a lower ratio of mature to immature animals would be expected than in a stable population. Kraus concluded that a GARR of about 0.048 was more likely, and estimated from actual counts that there were about 40% mature animals in the population. The existence of such a relatively small proportion of mature animals in the western North Atlantic population has yet to be verified. It is difficult to sample even 50% of the estimated total population within a single time period because of the practical problems posed by the distribution of animals. If it could be established, on the basis of repeated independent estimates, that the figure is valid, it could be the first evidence pointing to an increase in the stock size.

Accurate estimation of the number of newborns entering the population is also difficult because of the scattered distribution of the reproductive segment of the population between February and March. Any Right Whale less than 8 m in length can be considered to be a young-of-the-year (Kraus 1985). Since 1979 a total of 33 cows with calves have been recorded in the Gulf of Maine region and 29 in the lower Bay of Fundy in summer and early fall. From the ratio of this fraction to the total animals recorded, Kraus (1985) concluded that the minimum number of calves produced each year was between 7 and 12, with a mean of 9.2 ± 1.9. This yields a GARR of about 0.04. Even if a population proves to have a high GARR, it may be negated if the juvenile mortality rate is also correspondingly high. From a study of the available stranding data since 1970 (N = 12) Kraus (1985) found that 50% of all mortality occurred in the first year and 83% in the first three years of life. This assumes that all dead Right Whales strand, which they almost certainly do not; therefore these strandings must represent only part of the total mortality during that time.

Some questions remain about the age at sexual maturity, the average age at which the first calf is produced, and the length of the reproductively active life span, especially in females. the IWC (1986) workshop concluded that the average age at sexual maturity was 10 years, with the first birth at age 11. The life span is unknown, although at least one animal has been observed over a period of about 20 years.

Population Movements: There is little to add to the summary by Gaskin (1987), although succinct outlines of the known migrations of the western North Atlantic population were provided by Kraus et al. (1986), a publication not available when the previous article went to press.

Behavioural Adaptability: Watkins (1986) assessed the apparent impacts of various human activities, including whale-watching, on four species of large baleen whale in the Cape Cod region during 1957 to 1982. He concluded that Right Whales, which are not numerous enough to be a major target of the whale-watching boats that have operated during recent years, have shown no significant change in their reactions to boats. They remain relatively easy to approach and are relatively indifferent to boats travelling on a parallel course. My own observations and those of my group in the western Bay of Fundy are somewhat different; we have a strong impression that the adult Right Whales are now somewhat more wary than in 1981 and 1982 when whale-watching began. Conversely, certain individuals, especially some juveniles, show completely contrary behaviour, approaching the whale watching vessel to within distances of a few metres and circling it one or more times before resuming previous activities. During courtship sessions, adults appear virtually oblivious of boats, unless the engine revolution speed is changed suddenly. There is no indication that Right Whales have learned to take evasive action in the presence of medium-sized vessels. We have no data on their reactions to large ocean-going vessels, although such vessels are a known source of some mortality (Kraus 1985).

Limiting Factors

Loss of inshore habitat, competition for food resources with other species, and ship strikes, especially of inexperienced juveniles, have all been considered to limit recovery of the species (Winn 1982; Kraus 1985; Gaskin 1987). Best (1988) showed clearly that even a rather small number of incidental deaths in populations of small absolute size which have a long reproductive cycle can have a major impact on the rate of recovery. The problem of possible competition (Mitchell 1975) has yet to be fully explored, but Kraus (1985) noted that CeTAP data showed little or no overlap between Right Whale and Sei Whale summer distributions. The loss of important inshore habitat has tended to be taken for granted by almost all workers, simply because of the magnitude of the changes that have occurred on the eastern seaboard as a result of human population growth and coastal utilization (The Georgia Conservancy 1986). Pollution is another factor which is frequently raised in discussions. These aspects should be re-evaluated within the context proposed by Schevill et al. (1986), that Right Whales may have been rare for several centuries on the eastern coast of North America, and also within the findings of Scarff (1986), that even when Right Whales were still abundant in the North Pacific they were infrequent visitors to the west coast south of Alaska.

Special Significance of the Species

Right Whales are of great biological and ecological interest since no other marine mammal of this size feeds so low on the trophic chain. This may be one of the reasons that they show little population resilience to exploitation. In their time they were regarded as having great economic value, but they have now found a special place in the global public conservation conscience.

Evaluation

There is little to add to the summary Evaluation published in the earlier COSEWIC review (Gaskin 1987); we cannot measure the rate of increase in these populations at the present time with currently available methods. Indeed, we do not even know if such a recovery is occurring. The establishment of sanctuary areas for the winter calving grounds has been proposed (the Georgia Conservancy 1986), and similar status for the Brown's Bank area off Nova Scotia may be sought. Both these are laudable, but the critical area for cows and calves is still the lower Bay of Fundy, where establishment of a sanctuary might meet all kinds of objections from the fishing industry. It would also be difficult to restrict the movement of large cargo vessels to and from Saint John much more than they are already limited by the local topography and shoal areas. The most useful conservation measure might be to try to minimize juvenile mortalities by educating marine operators, and by issuing special instructions to navigators and, where necessary, closing specific areas to gill-netting operations.

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Status of the Belugas, *Delphinapterus leucas*, of Southeast Baffin Island, Northwest Territories*

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Richard, P. R. 1991. Status of the Belugas, *Delphinapterus leucas*, of southeast Baffin Island, Northwest Territories. Canadian Field-Naturalist 105(2): 206-214.

The Southeast Baffin Island Beluga population ranges from Cumberland Sound to the eastern portion of Hudson Strait. Belugas from this population show morphometric differences when compared with Belugas from neighbouring populations. Also, they have declined considerably in numbers as a result of commercial hunting. Therefore, it is thought that they constitute a separate genetic stock. The annual quota of 40 which limits the catch of Belugas inside Cumberland Sound is now thought to be excessive. There are presently no limits on the number of Belugas caught outside of Cumberland Sound and recent information suggests that the stock is also hunted in Frobisher Bay and Lake Harbour. The current annual removals by hunting cannot be sustained by the stock, estimated in 1986 at less than 500, and the stock is thought to be declining. Unless protected, it runs the risk of being eradicated within the next decade. Therefore, it is recommended that the southeast Baffin Beluga stock be considered Endangered.

L'aire de distribution de la population de Bélugas du sud-est de la Terre de Baffin s'étend de la baie de Cumberland à la portion est du détroit d'Hudson. Les Bélugas appartenant à cette population ont des caractéristiques morphométriques différentes de celles des Bélugas de populations voisines. On pense donc qu'ils forment un stock génétique différent de ces derniers. Les captures de Bélugas dans la baie de Cumberland sont limités par un quota annuel de 40 mais on croit maintenant que ce quota est excessif. Il n'y a présentement pas de limites imposées sur le nombre de captures en dehors de la baie de Cumberland. Pourtant, des informations récentes suggèrent que le stock du S.E. de la Terre de Baffin est également chassé dans la baie de Frobisher et autour de Lake Harbour. Le stock, dénombré en 1986 à moins de 500, ne peut supporter la présente mortalité annuelle causée par la chasse. On croit donc que le stock est en déclin et qu'il court le risque d'être extirpé en moins de dix ans. On recommende que le stock du sud-est de la Terre de Baffin soit considéré en danger de disparition.

Key Words: Beluga, Belukha, White Whale, Baleine blanche, Béluga, *Delphinapterus leucas*, stock size and trend, southeast Baffin Island, Cumberland Sound.

The Beluga, White Whale, or Belukha, *Delphinapterus leucas* (Pallas 1776), is an odontocete cetacean of the family Monodontidae. It has a blunt head, a slight beak and a fat, stocky body (Figure 1), and like its relative, the Narwhal (*Monodon monoceros*), lacks a dorsal fin. Young animals are slate or brown coloured and become progressively lighter coloured as they mature (Figure 1). Adults are generally pure white but their skin may appear a light shade of yellow in spring or early summer during the molt. Lack of a dorsal fin and a thick skin are characteristics of ice-adapted cetaceans shared by the Beluga.

There are differences in size and weight among Belugas of different geographical locations (Sergeant and Brodie 1969). Cumberland Sound Belugas are medium-sized animals; female and male adults of age 10 or more reach mean lengths of 362 cm and 427 cm respectively (Brodie 1971) and weigh about 800 to 1000 kg. Newborn calves average 160 cm and 78 kg. Comparisons of length and girth at age indicate that Cumberland Sound Belugas are larger than Belugas from neighbouring Hudson Bay populations (Sergeant and Brodie 1969; Finley et al. 1982; R. E. A. Stewart, Department of Fisheries and Oceans [DFO], Winnipeg, Manitoba; personal communication). These morphometric differences suggest that Southeast Baffin Island Belugas are an isolated genetic stock. This conclusion is reinforced by the large decline in numbers that the population has suffered throughout its history of commercial and subsistence exploitation (Mitchell and Reeves 1981; *see also* Limiting Factors, below).

Distribution

Belugas are widely distributed in arctic and sub-arctic waters of North America (Figure 2). Their historical range is not precisely known, but whaling archives confirm their presence in summer in the areas that they presently occupy (Mitchell and Reeves 1981; Ross and McIver 1982). Along

*Endangered status approved and assigned by COSEWIC 11 April 1990.

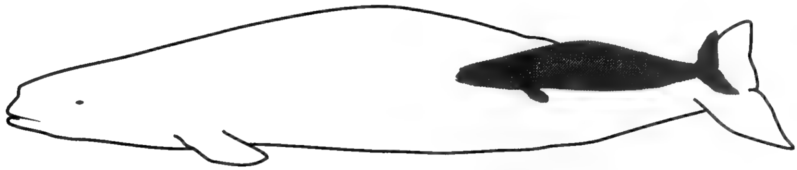

FIGURE 1. Adult (white) and calf (dark) Beluga, Belukha, or White Whale.

southeast Baffin Island, Belugas concentrate in summer at the head of Cumberland Sound, particularly at the Ranger River estuary in Clearwater Fiord (Figure 3). They also occur in small numbers along the south coast of Cumberland Sound, the coast of Hall Peninsula and inside Frobisher Bay (Richard et al. *in press*). Monthly catch records also indicate that some Belugas also summer near Lake Harbour (D. Pike, DFO, Iqaluit, Northwest Territories, personal communication; *see* Limiting Factors). Spring and fall migrations, respectively north and south bound, are thought to take place along the coast of Hall Peninsula (Richard and Orr 1986). These movements correspond to the predominantly spring and fall hunting pattern of Iqaluit (Frobisher Bay) and Lake Harbour hunters (Richard and Orr 1986). The winter distribution of southeast Baffin Belugas is not clear, but is thought to range from the mouth of Frobisher Bay southward (Figure 3), and to overlap with the winter range of Hudson Bay populations which occupy Hudson Strait and western Davis Strait in winter (Richard and Orr 1986).

Protection

Beluga management in Canada is conducted by the Department of Fisheries and Oceans (DFO) under the authority of the Fisheries Act of 1867 and the Beluga Protection Regulations, as amended to date, which provide for the protection of habitat, management of the species, and control of the harvest.

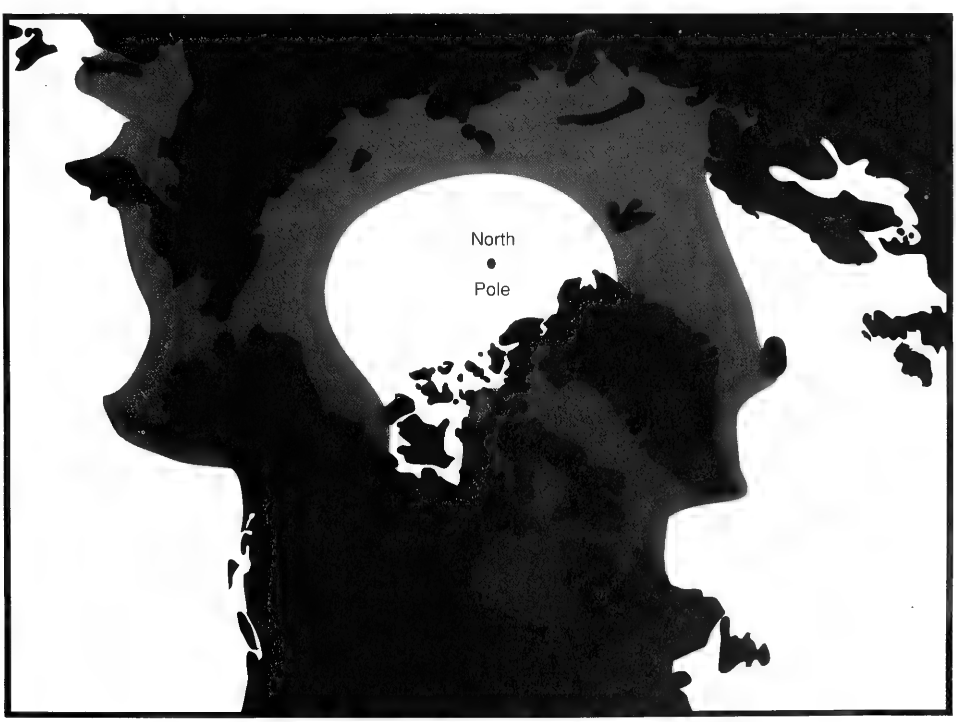

FIGURE 2. Circumpolar distribution of Belugas (based on Stewart and Stewart 1989).

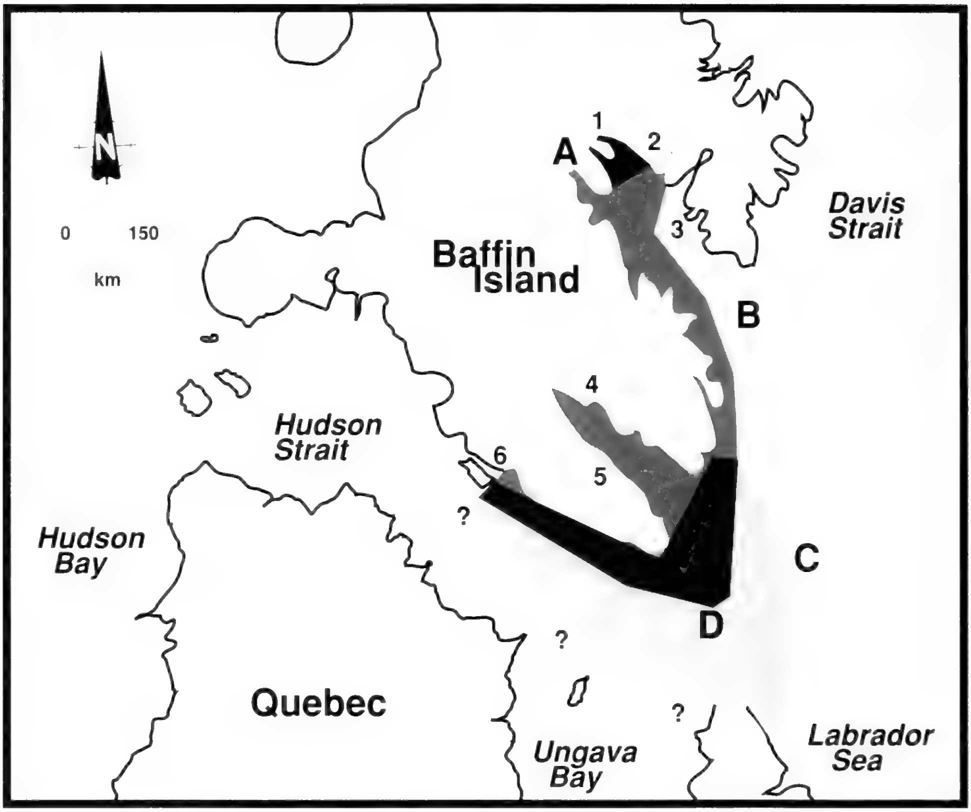

FIGURE 3. Seasonal distribution of southeast Baffin Island Belugas. (A) Summer Concentration; (B) Summer Range; (C) Overlap of Summer and Winter Range; (D) Winter Range; (?) Limits of Winter Range Unknown. Place Names: (1) Ranger River Estuary, Clearwater Fiord; (2) Pangnirtung; (3) Cumberland Sound; (4) Igaluit (Frobisher Bay); (5) Frobisher Bay; (6) Lake Harbour.

The Beluga Protection Regulations limit Beluga hunting without a permit to the Indian and Inuit natives of Canada. A native resident of the Northwest Territories, Yukon, or northern Quebec may take Belugas for food, for himself and his family, or may trade or barter Belugas within the Northwest Territories and northern Quebec with other native residents.

In the Southeast Baffin Island area, an annual quota of 40 for the catch of Belugas inside the waters of Cumberland Sound was enacted in the Regulations in 1980. There was, until now, no limit on the number of Belugas taken outside of Cumberland Sound. Recent information suggests that the stock is also hunted in Frobisher Bay and possibly near Lake Harbour. Since 1979, DFO has held many information meetings and distributed Inuktitut brochures explaining the results of studies on this stock and their implications for population management. In January 1990, the newly-formed Nunavut Wildlife Management Board, an advisory committee composed of Federal officials and Inuit hunter representatives, recommended that the harvest on this stock be limited to a total of 15 per year for the next two years and that during this time further assessment of stock size can be done. They further recommended that the 15 be divided equally between the three communities of Pangnirtung, Iqaluit and Lake Harbour. Regulations are being changed to reflect these recommendations.

Non-native hunting is controlled by licences which can be issued to a person who wishes to obtain food for himself, his family and his dogs. No permit has been issued in Southeast Baffin communities.

The Beluga Protection Regulations also established conditions that should be met by all Beluga hunters. They state that reasonable effort must be taken to retrieve any animal killed or wounded during a hunt and that wastage of any parts suitable for food is prohibited. Hunting of

calves and females accompanied by calves is prohibited and hunters are prohibited from hunting Belugas with rifles of 0.22 calibre or less and must have a boat and a harpoon with a line and float attached while hunting. Finally, with the exception of hunting activities, there is a general prohibition on willful disturbance of Belugas. DFO has guidelines for non-hunting activities which may otherwise cause disturbance to Belugas.

Population Size and Trends

In the decades following 1923, large commercial catches for Belugas are thought to have caused a decline in numbers until commercial hunting stopped in 1960 (Mitchell and Reeves 1981). Surveys of Clearwater Fiord in the summer of 1967 resulted in an estimate of about 769 animals (Brodie et al. 1981). The Cumberland Sound population before 1923 was estimated to number more than 5000 animals (Mitchell and Reeves 1981). This estimate is a rough back-calculation from the 1967 estimate of 769 animals and estimates of commercial and subsistence catches. The authors also assumed that, throughout its history of exploitation, the population had an annual rate of recruitment equal to 8% of total population size. We will see later (Reproductive Biology and Mortality) that annual recruitment is probably lower than 8%, which means that there were probably many more than 5000 Belugas in 1923. In addition, the 1967 estimate covered only the Clearwater Fiord area of concentration; it did not cover the entire range of Belugas along southeast Baffin Island. Therefore, we cannot derive from such data a precise trend of abundance. We can only conclude, as did the above-mentioned authors, that the stock has suffered a substantial decline in abundance over the period between 1923 and 1967.

Surveys made during the summer of 1979-1980, and which covered the head of Cumberland Sound, indicated that only 400 to 600 animals remained (Brodie et al. 1981; Richard and Orr 1986). Groups of Belugas ranging in size from two to over 100 were also seen in Frobisher Bay (MacLaren-Marex 1978, 1979, 1980) during the period of concentration in Cumberland Sound, indicating that the summer range of Belugas in southeast Baffin Island was not limited to Cumberland Sound.

In August of 1985 and 1986, an attempt was made to cover the entire range of Belugas along southeast Baffin Island, flying surveys over Cumberland Sound, Frobisher Bay and coastal areas of Hall and Meta Incognita Peninsula (Figure 3). During the 1985 survey a total 407 Belugas were sighted, the majority (398) of which were found in the Ranger River estuary at Clearwater Fiord (Richard et al. *in press*). Nine were also sighted near the mouth of Frobisher Bay but none were seen along Hall Peninsula or on the Hudson Strait side of Meta Incognita Peninsula.

During the 1986 surveys, 442 Belugas were photographed from the air near the mouth of Clearwater Fiord and at the same time, 43 were counted from a cliff in Clearwater Fiord. Two more were sighted in Kangilo Fiord and one in Cyrus Field Bay, off Hall Peninsula. No correction factors for submerged animals were applied to these counts, but the 442 Belugas photographed in 1986 were in very clear water and travelling fast, making short, shallow dives. Few submerged animals, if any, were missed by the camera. The 43 whales counted from a cliff in Clearwater Fiord were in the silted waters of the Ranger estuary but they were relatively easy to count because whales were dispersed and the observer had all the time needed to wait for surfacing whales. The difference in herd count between 1985 and 1986 is most likely due to the fact that the 1985 photographs were taken while the herd occupied silted waters which allowed little depth penetration.

A population estimate cannot be derived from this data because of the extreme clumping of this relatively small population. Because so few Belugas, other than the compact herd at the head of Cumberland Sound, were seen in both years despite the extensive coverage, it was concluded that there were fewer than 500 Belugas in the southeast Baffin summer population in 1986. Since then, between 1987 and 1989, close to 300 Belugas have been removed by Pangnirtung, Iqaluit and Lake Harbour hunters (*see* Limiting Factors) while the net recruitment during those three years was probably fewer than 15 animals (*see* General Biology).

Consequently, unless population size or recruitment have been grossly underestimated, or Belugas from other stocks have recruited into the population, the southeast Baffin stock must now be smaller than the numbers observed in 1986. At the present rate of exploitation, it must be declining and could be extirpated in less than a decade.

Habitat

Most southeast Baffin Belugas concentrate at the head of Cumberland Sound in summer, particularly in the small Ranger River estuary of Clearwater Fiord. It has been postulated that Belugas, neonates in particular, can reduce their energy expenditures while occupying warm estuarine waters (Sergeant and Brodie 1969). Thyroid hormone production increases during estuarine occupation, suggesting that growth is enhanced during summer (St-Aubin and Geraci

1989). It is hypothesized that warm estuaries provide a less energetically demanding environment at a time when their fat reserves are mobilized for growth (St-Aubin and Geraci 1989). Belugas also molt their skin in summer and have been observed rubbing themselves on the bottom (Finley et al. 1982). Although stomachs examined revealed a variety of food species, Belugas occupying Clearwater Fiord did not appear to feed extensively (Brodie 1970). In addition to those in the Ranger River, Belugas are occasionally seen in small numbers in the McKeand River of Cumberland Sound but we know of no report of Belugas in other estuaries of southeast Baffin Island.

The winter habitat of southeast Baffin Island Belugas is poorly delimited (*see* Distribution). They are thought to occupy areas of Davis Strait and western Hudson Strait (Richard and Orr 1986). In Hudson Strait, Belugas were found in higher numbers in loose pack (26%-75%) than in heavy pack ice while no Beluga was seen in ice-free waters east of the pack (McLaren and Davis 1982). There is no information on trends in quality and quantity of habitat.

General Biology

Reproductive Biology and Mortality: Estimates of life history parameters for Southeast Baffin Belugas were obtained by sampling animals caught at Clearwater Fiord (Brodie 1969, 1971). Animals were aged by counting dentinal growth layers on longitudinal thin sections of teeth. There has been some controversy over whether one or two growth layers are deposited every year (Brodie 1969; Sergeant 1973; Braham 1984) but evidence from a few captive animals has confirmed the two annual growth layer hypothesis (Brodie 1982; Goren et al. 1987). Age is therefore estimated as half the number of growth layers. Tooth wear complicates the aging of older animals by removing the layers deposited at the apex of the teeth (Sergeant 1973). Consequently, maximum lifespan cannot be ascertained precisely but studies of tooth and mandibular layers suggest that the oldest animals probably reach 30 years (Brodie 1969).

Southeast Baffin Beluga females reach sexual maturity at about age five on average and give birth to a single calf after a gestation of about 14.5 months (Brodie 1971). Calves are suckled for at least two years and the calving interval is estimated to be three years (Brodie 1971). Breeding has never been observed but is thought to peak in the month of May. Calving takes place from late July to mid-August the following year (Brodie 1971).

The net annual recruitment rate (NARR) is not known because age-specific mortality rates cannot be estimated from existing data. There are few estimates of NARR for cetaceans; those that are available for Odontocetes, Killer Whales (***Orcinus orca***) and Striped Dolphins (***Stenella coeruleoalba***), range from 1.7% to 3.2% (Perrin and Reilly 1984). Gray Whale (***Eschrichtius robustus***) NARR was also estimated at 2.3 to 2.5% with 95% confidence limits of 0.33 to 4.43% (Reilly 1987). This suggests that Belugas, like other cetaceans with similar reproductive biology, might also have a NARR as low as 2 to 3% of total population size, a conclusion supported by attempts to model population growth (Richard and Orr 1986; Béland et al. 1988).

Despite a hunting bias for large animals (Orr and Richard 1985), the oldest female in recent samples of the catch from Cumberland Sound was 17 years old, compared to 21 and 26 years, respectively, in catch samples from Grise Fiord and Eskimo Point (Stewart, personal communication). If this is an indication of population age structure, the reproductive component of the population appears to have been truncated. If so, the southeast Baffin population does not fit normal assumptions of models of population growth and its growth rate could be less than 2 to 3%.

Feeding: Inspection of stomach contents from Belugas caught in Clearwater Fiord indicate that Belugas feed on a variety of prey species in summer (Brodie 1970). They include benthic organisms such as gastropods, polychaete worms and ascidians, but pelagic species, Arctic Cod (*Gadus ogac*), squid (*Gonatus fabricii*), and various species of shrimps, were found most frequently. No quantitative analysis was made of the stomach contents but Brodie (1970) thought that they did not feed extensively during their stay in Clearwater Fiord. Digestion in odontocete whales is rapid and little soft tissue may remain in their stomachs a few hours after ingestion (Finley and Gibb 1982). Consequently absence of food in the stomach of Belugas could be a consequence of the delay between feeding and sampling rather than a function of feeding activity. The winter diet of Southeast Baffin Belugas is not known.

Species Movement: The stock's summer habitat is coastal waters of southeast Baffin Island while its winter habitat is thought to be in the loose pack of Davis Strait and eastern Hudson Strait (*see* Distribution). The stock is therefore considered relatively sedentary since it need only travel a few hundred kilometers to reach either summer or winter habitats compared to the thousand or more kilometers travelled by other stocks in spring and fall.

Behaviour and Adaptability: Belugas react to hunters by making long dives and surfacing 500 to

800 m away from the observer (J. Orr, DFO Winnipeg, Manitoba, personal communication). Continued harassment will cause Belugas to temporarily vacate Clearwater Fiord but they stubbornly return to the Ranger River estuary, usually within a few hours, sometimes after a few days of absence (Orr, personal communication).

Limiting Factors

There is no evidence that Southeast Baffin Belugas have been affected by habitat loss or that they suffer from direct or indirect environmental contamination. Potential limiting factors include ice entrapment (Mitchell and Reeves 1981; Brodie 1982), predation by Polar Bears, *Ursus maritimus*, and Killer Whales, *Orcinus orca* (Smith 1985; Lowry et al. 1987a,b), and shallow water entrapment (L. Dahlke, DFO Iqaluit, Northwest Territories, personal communication). Shallow water entrapment results when Belugas are stranded on river bottoms at low tide. Belugas have been repeatedly observed stranding in this way at Cunningham Inlet, but all have escaped with high tide (Smith *in press*). During neap tides of July 1986 and 1988, small pods were trapped in the McKeand River, unable to escape for several weeks (Dahlke, personal communication). Had they not been caught by hunters, we suspect that they would have died eventually from predation or starvation.

The contribution of the above-mentioned factors to overall natural mortality is difficult to quantify and has not been estimated. Human predation is by far the most important factor in the decline of the Southeast Baffin Beluga stock. Commercial exploitation in Cumberland Sound, mostly at Clearwater Fiord, from the early 1920s to the late 1950s resulted in the removal of several hundred animals each year (Figure 4). The decline of catches in the 1950s ended the commercial hunt, but hunting for local consumption continued. Between 1976 and 1979, Cumberland Sound catches increased again (Figure 5) in response to demands for intersettlement trade of muktuk (whale skin) for human consumption. Surveys of Cumberland Sound in 1978 and 1979 indicated that there were too few Belugas to support such a large catch (Brodie et al. 1981). Brodie et al. (1981), having estimated annual recruitment at 7.5% of population size, recommended that the annual catch in Cumberland Sound not exceed 40 animals. Regulation changes to that effect were enacted in 1980.

Our distributional data showed that the Southeast Baffin stock is not hunted only in Cumberland Sound, but also in Frobisher Bay and that they could also be taken by Lake Harbour hunters (*see* Distribution). Recent information on the monthly distribution of catches in Lake Harbour (Pike, personal communication) shows catches in July when Hudson Bay Belugas have presumably vacated the area. This lends support to the idea that part of the Lake Harbour catch belongs to the Southeast Baffin Beluga stock.

Richard and Orr (1986) concluded that hunt losses could be in the order of 10% to 30%. The annual landed catch of Belugas in Pangnirtung and Iqaluit in the last three years has averaged 83 per

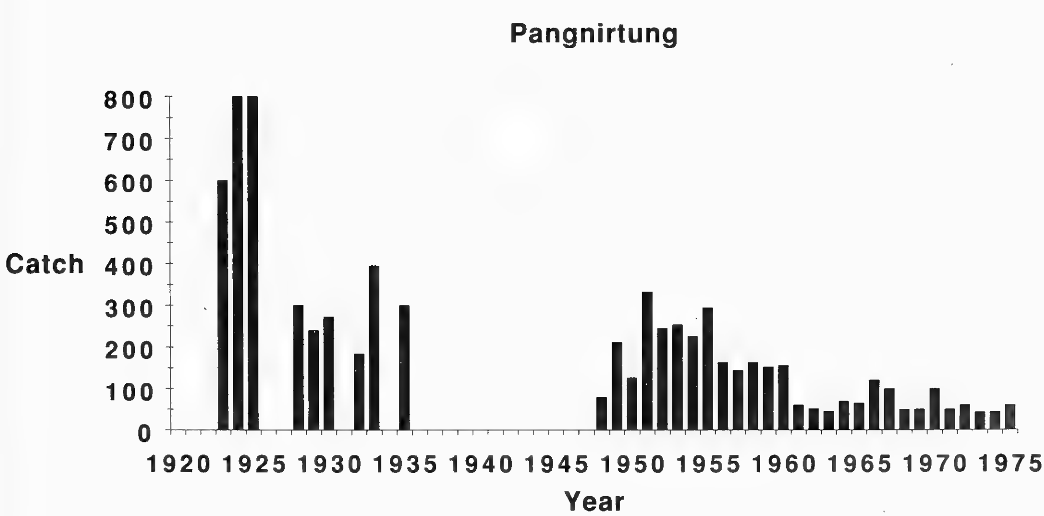

FIGURE 4. Historical annual Beluga catches in Cumberland Sound, 1923 to 1975 (Kemper 1980; Mitchell and Reeves 1981). Note: catch records are unavailable for 1926-1927 and 1936-1947.

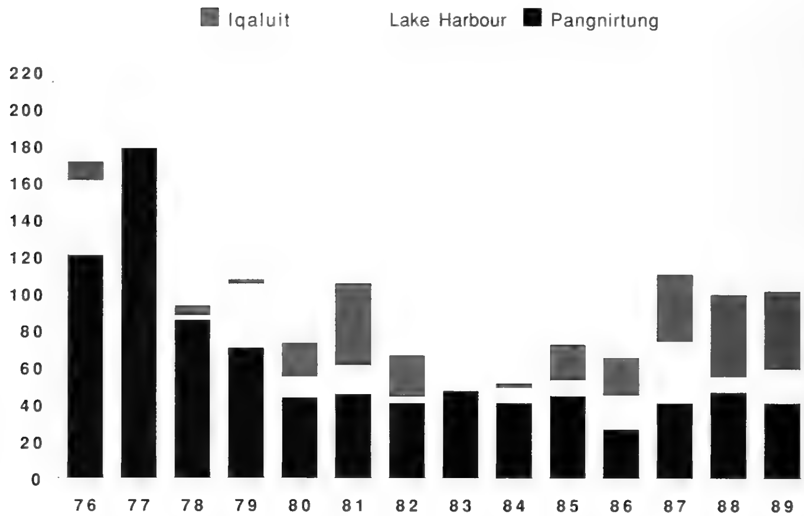

FIGURE 5. Recent annual Beluga catches in Cumberland Sound, Frobisher Bay, and around Lake Harbour, 1976-1989 (DFO annual catch statistics).

year (Figure 3), more than 17% of the 1986 Southeast Baffin stock size ("less than 500") which, when adjusted for a 10% to 30% hunting loss, indicates an annual removal rate of 92 to 119 animals or more than 18 to 24% of 1986 stock size. If a Lake Harbour annual catch that could be between 10 (July 1989 catch) and 21 Belugas (average annual catch 1987-1989) is added, the total annual removal could be as large as 100 or more. At rates of 2 to 3%, the growth potential of the stock is already slight. If there was no hunting, the Southeast Baffin population might increase slowly and double its present size in half a century or more, but even then it would still not sustain the present annual catch.

Low population size can accelerate or even cause extinction by random occurrences of high death rates and low birth rates (Gilpin and Soulé 1986). Small populations run the risk of random loss of genetic variance which, in turn, can reduce birth rate, and increase mortality and the likelihood of demographic extinction. These processes can be exacerbated by random changes in the quality of the environment or by catastrophic events. The recent phocine distemper epidemic which wiped out at least half of the North Sea Harbour Seal population in six months (Harwood 1989) is a good example of such a catastrophic event.

Of course, there are examples of overharvested marine mammals rebounding to large numbers after a period of protection, for example Northern Elephant Seals (*Mirounga angurostris*), but lacking a pool of genetic variability with which to adapt to changing conditions, these species are especially vulnerable to environmental modification (Bonnell and Selander 1974). There are other examples of overharvested species which, despite long periods of protection, have not shown any signs of recovery, Right Whales (*Eubalaena glacialis*) for instance (Reeves et al. 1978).

The larger a population, the safer it is from catastrophes and from the negative effects of demographic, genetic and environmental stochasticity. It is difficult to estimate precisely what population size would ensure long term survival for Belugas, particularly when many aspects of life history are poorly understood, but several lines of evidence suggest that, for mammals in general, minimum population sizes for long term survival are one thousand to several thousand individuals (Soulé 1987).

Special Significance of the Species

The Beluga is one of the few truly arctic whale species, living year-round in ice-covered waters and exhibiting several adaptations for its arctic environment. It is an important resource for the Inuit. The skin or "muktuk" is a favoured food which is rich in nutritive value and often in short supply in many communities. Consequently, there is a great demand for trade in muktuk from communities which have fewer opportunities to hunt Belugas. The hunting of Belugas in southeast Baffin Island has long been an important cultural and subsistence activity for a people to whom hunting and culture are synonymous and whose diet is composed largely of wild foods.

The pure white colour of the Beluga, its gregariousness and concentration in easily accessible estuaries have made it a popular tourist attraction. Belugas are also kept in several North American aquaria and their docility and playfulness have captured the public's imagination. Recently, attention has focused on the decline of the Saint Lawrence River Beluga population which also numbers about 500 animals (Sergeant 1986) and which has received an Endangered listing by COSEWIC (Pippard 1985). A second stock, the Ungava Bay population, has been all but eradicated by hunting (Smith and Hammill 1986) and is also classified as Endangered (Reeves and Mitchell 1989). The Southeast Baffin Beluga stock is the third Canadian stock which has been reduced to the point where its survival is Endangered. It requires immediate and total protection.

Evaluation

The Southeastern Baffin stock has declined sharply due to excessive commercial harvesting and continues to decline because subsistence harvesting greatly exceeds the potential for increase of the remnant population. If total protection is afforded to this stock it might increase slowly, but recovery to a level of over a thousand could take half a century or more and would still not sustain the present levels of hunting (*see* General Biology). Any removal by hunting will further decrease the stock's size and greatly diminish its survival chances. Continued harvesting and hunting losses at the present rate will result in the stock being eradicated in less than a decade.

Therefore, the Southeastern Baffin Beluga stock should be considered Endangered as defined by COSEWIC: "Any species of fauna or flora whose existence in Canada is threatened with immediate extinction through all or a significant portion of its range, owing to the action of man" (Cook and Muir 1984).

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Status of Cuvier's Beaked Whale, *Ziphius cavirostris*, in Canada*

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Houston, J. 1991. Status of Cuvier's Beaked Whale, *Ziphius cavirostris*, in Canada. Canadian Field-Naturalist 105(2): 215–218.

Cuvier's Beaked Whale, *Ziphius cavirostris*, is cosmopolitan in temperate and tropical waters and occurs irregularly along the Atlantic and Pacific coasts of Canada. It is a pelagic species which appears to be confined by the 10°C isotherm and the 1000m bathymetric contour. These whales are seldom seen alive and are known mainly from occasional stranded specimens. Cuvier's Beaked Whale is not of commercial interest and is a rare species in Canadian waters.

La Baleine à bec de Cuvier, *Ziphius cavirostris*, est une espèce cosmopolite qui fréquente les eaux tempérées et tropicales. Elle est présente à l'occasion dans les eaux côtières canadiennes de l'Atlantique et du Pacifique. L'aire de répartition de cette espèce pélagique semble être restreinte par l'isotherme de 10°C et par la courbe de niveau bathymétrique de 1000m. Étant donné que cette baleine est rarement observée en mer, les connaissances dont on dispose proviennent surtout d'individus échoués. Elle ne fait pas l'objet d'une chasse commerciale et constitue une espèce rare dans les eaux canadiennes.

Key Words: Cuvier's Beaked Whale, Goose-beaked Whale, Baleine à bec de Cuvier, *Ziphius cavirostris*, Ziphiidae, odontocetes, status, Canada.

Cuvier's Beaked Whale, *Ziphius cavirostris* Cuvier 1823, is an odontocete or toothed whale of the family Ziphiidae. Also referred to as the Goose-beaked whale, or, in French, as baleine à bec de Cuvier, or ziphius de Cuvier, it is a small whale, weighing three to four tonnes. Adult males average 5.5 m in length, females are usually slightly larger, averaging 5.8 m. Calves are about two to three m at birth (Watson 1981; Hoyt 1984; Mead 1984).

These whales (Figure 1) are robust with the spindle-shaped body typical of the ziphiids. The head is small with its forehead sloping to a relatively short beak which, with the peculiar, curved mandible, resembles a goose-beak. Conical teeth erupt only in males, one on each side at the tip of the lower jaw. The flippers are small and fold into fleshy pockets on the flanks. The curved dorsal fin is up to 40 cm in height and is placed well back on the body. The tail is small for the size of the animal and has a slight notch in the center of the flukes (*see* Watson 1981; Hoyt 1984).

The colour varies from tan to light brown in the Pacific and grey to smoke blue in the Atlantic. The back is usually darker than the ventral surface, although the pattern may be reversed in some individuals (Watson 1981). The head is usually lighter and may be almost white in some adult males. Oval white patches on the ventral surface and flanks are common and thought to be caused by lamprey or by the parasitic crustacean *Livoneca ravnaudi*. Double-tracked scars on the back of the older males are probably produced by other males (Watson 1981).

Distribution

Ziphius cavirostris has a world-wide distribution in deeper, offshore tropical and temperate waters, usually outside the 1000 m contour (Figure 2). They are rarely found in polar waters (Klinowska 1980).

Most of what is known of these whales in Canadian waters comes from a few stranded animals which have come to the attention of scientists (Reeves and Mitchell 1987). Mitchell (1968,1975a,1975b) has listed about 40 strandings of this species along the western North American coast as far north as Alaska and this whale may be expected to appear irregularly along the Atlantic coast (Reeves and Mitchell 1987). True (1910) considered that skulls he examined of beaked whales which had been taken from the North Atlantic represented *Ziphius cavirostris*.

Protection

International: Cuvier's Beaked Whale is listed under Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Such listing requires regulation of trade in live specimens, parts, and derivatives by those countries party to the Convention, and trade must be covered by an appropriate Convention export permit issued by

*Report accepted by COSEWIC 11 April 1990 — no status designation required.

FIGURE 1. Cuvier's Beaked Whale, *Ziphius cavirostris*.

the Government of the exporting nation before entry to another party nation is allowed. Currently, there are over 100 nations which are Parties to the Convention.

National: All cetacea are protected in Canadian waters under the Fisheries Act of 1867 (and amendments thereto) and the Cetacean Protection Regulations promulgated under the Act. Whales are protected in United States waters under the Marine Mammal Protection Act of 1972 as well as by the Packwood-Magnuson Amendment of the Fisheries and Conservation Act and the Pelly Amendment of the Fisherman's Protective Act.

Population Sizes and Trends

No information is available on population status. Mitchell (1975b) regarded the species as inderminate in status, in agreement with Goodwin and Holloway (1972). Study of Pacific specimens indicates that the Pacific population represents a single, widespread, but morphologically variable stock (Mitchell 1968; Omura 1972). Atlantic specimens have not been as thoroughly studied but the situation is probably similar to that in the Pacific.

Strandings are known in the western Atlantic from Nova Scotia along the eastern United States seaboard south to Florida; in the eastern Atlantic Ocean strandings have been reported along the coasts of Britain, Spain, and the Mediterranean. Stranded animals are also known from South America, South Africa, Australia, and New Zealand (Gaskin 1972; Watson 1981). In the Pacific, strandings are recorded for Japan, the Midway Islands, Hawaii, California, Mexico, Canada, and Alaska (Mitchell 1968; Watson 1981). Mass strandings are unknown, although the frequency of individual strandings is greater in some areas, such as along the east coast of New Zealand, and at Genoa on the Italian coast (Watson 1981).

Cuvier's Beaked Whale is found off Japan the year round (Omura et al. 1955) and a number of these whales are taken each year by Japanese coastal stations (Klinowska 1980). There is no evidence that the species is being overfished (Mitchell 1975b; Watson 1981). An occasional Cuvier's Whale is known to have been taken in the small whale fishery at St. Vincent in the Caribbean (Mitchell 1975b; Watson 1981), but it is otherwise not exploited in the Atlantic.

Mitchell (1975 a,b) felt that the perceived rarity of the species may be due more to the lack of systematic census than to scarcity of the animals *per se*. Mead (1984: 95) stated that, "this is a more common ziphiid, perhaps the most common in terms of absolute numbers".

Habitat

Ziphius cavirostris appears to be a pelagic species venturing near the continental land masses (Hoyt 1984). They seem to be confined by the 10°C isotherm and are not often found in colder waters, although there is some evidence for summer movement to higher latitudes (Watson 1981). The whale's frequenting of deeper water ($\geq$ 1000m) may be related to food requirements. The species is reported to consume squid and deepwater fish, although crabs and starfish are also be eaten (Watson 1981; Hoyt 1984).

General Biology

Pelagic species such as Cuvier's Beaked Whale are rarely seen alive at sea and details of their natural history are not well known. Mitchell (1975a) indicated that lengths at sexual maturity were approximately 6.1 m for females, and 5.5 m for males, and that length at birth ranged from 2 to 3 m. Omura et al. (1955) recorded average lengths of sexually mature females at 5.8 m and at 5.5 m for males in the Northern Pacific. The shortest mature female recorded was 5.3 m and the longest 7.5 m, the largest male was 7.0 m (Mead 1984). Some few specimens have been aged by counting incremental growth layers of hard tissue (e.g. teeth). Mead (1984) reports maximum recorded

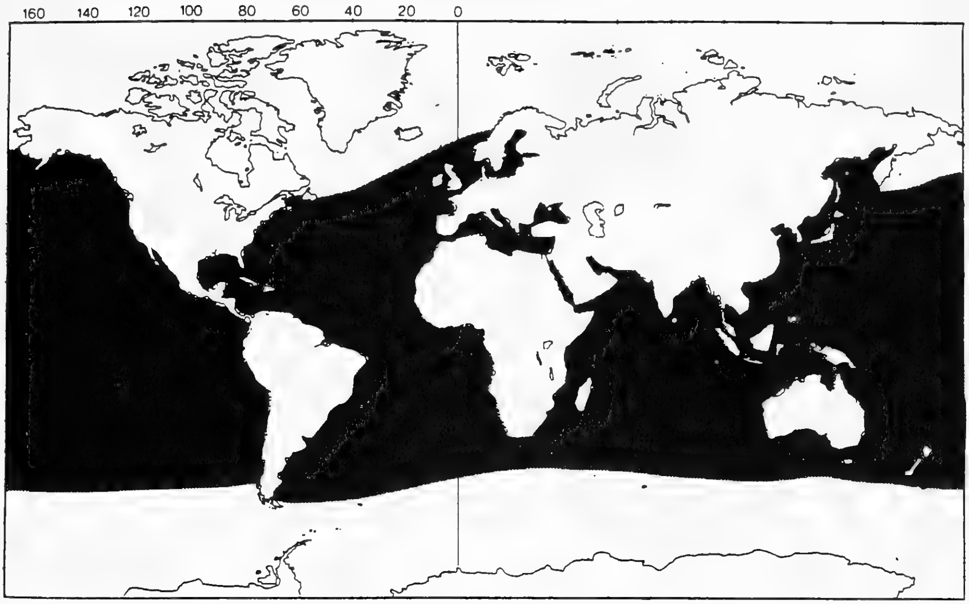

FIGURE 2. Distribution of Cuvier's Beaked Whale, *Ziphius cavirostris*.

age at 30 GLGs (growth layer groups) for a female and 36 GLGs for a male (the term is generic and may correspond to the amount of hard tissue formed during one year).

Oshumi (1964) has studied ovarian material, but insufficient sample sizes precluded conclusions on life-cycle or age (*see also* Mead 1984). The gestation period is not known, but calves appear to be born year round (Watson 1981). Foetal length has been reported to vary from 1.4 to 2.7 m and a mean estimates for length at birth at 2.7 m (Mead 1984).

Solitary bulls are occasionally seen (Watson 1981; Hoyt 1984) but these whales are most frequently observed in pods of three to five individuals. Larger groups of 10 to 15 may represent extended families (Watson 1981). Gaskin (1981, 1982) indicates that the beaked whales are the least social of the medium-sized odontocetes which may account for the lack of mass strandings, even though the species strands more often than other ziphiids (Watson 1981).

There is no evidence of migratory behaviour by the species (Gaskin 1972) but there may be some general north-south movements (Watson 1981). The reason for strandings of this species are still unknown (Watson 1981), but the fact that the species is found beached more often than other ziphiids may reflect an ubiquitous distribution and greater relative abundance.

Cuvier's Beaked Whales are strong swimmers but usually travel at a leisurely pace of 5 to 6 kph. On deeper dives, the average submersed time is about 30 minutes. Deep dives may be preceded by a vertical raising of the fluke. The animals are also known to breach occasionally (*see* Watson 1981; Hoyt 1984).

Limiting Factors

None known. The species is exploited commercially along the coast of Japan (Omura et al. 1955) but there is no firm evidence that the species is being overfished (Mitchell 1975 a,b).

Special Significance of the Species

Most of what is known about the beaked whales in Canadian waters comes from the few specimens stranded on our shores. Cuvier's Beaked Whale is cosmopolitan in temperate and tropical seas on the Pacific and Atlantic coasts (Reeves and Mitchell 1987).

The species is not particularly sought after by commercial whalers. A small food fishery exists in Japan and in the Lesser Antilles, specimens being taken as the opportunity arises. Between 13 to 60 are taken yearly in the Japanese fishery (Klinowska 1980) and only one or two specimens have been taken in the Lesser Antilles (Caldwell and Caldwell 1975). Three specimens were apparently taken in France between 1971 and 1976 (Duguy 1977). Stranded specimens along the coast of the U.S.S.R. are utilized for food for dogs and foxes (Tomilin 1957).

The species is not known in trade and there is no demand for parts and derivatives. The species has not been maintained in captivity, although one

ailing individual was held for a few days in the United States. (Norris and Prescott 1961).

Evaluation

Cuvier's Beaked Whales are small odontocetes of the open seas which are widely dispersed in temperate and tropical waters. Although it is perhaps the most common of the ziphiids, its occurrence in Canadian waters is rare. The rarity of the species along the North American Pacific and Atlantic coasts may be more a product of the lack of systematic survey than actual scarcity of specimens (Mitchell 1975b).

The Canadian distribution is probably at the edge of its temperate zone range, reported occurrences here are rare and the species is not subject to any threat in Canadian waters at this time. No COSEWIC status is currently warranted or required.

Acknowledgments

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Status of the Pacific White-sided Dolphin, *Lagenorhynchus obliquidens*, in Canada*

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The Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*) appears to be an abundant permanent resident of the pelagic waters off the west coast of Canada and a regular visitor to inshore waters. This report summarizes the general biology and management of this species with special reference to its status in Canada. One hundred and fifty-six records from Canada's 320 km (200 mile) extended economic zone are presented. Group size ranges from 1 to 1000, with a mean, median and modal size of 62, 15 and 6 respectively. Depth of water from sighting locations ranges from 10 to 2000 fathoms, with mean, median and modal depths of 617, 400 and 100 fathoms, respectively. Sea surface temperature taken at 73 record locations had a range from 6° to 17°C, with a mean, median and mode of 12°, 13° and 15°C respectively. The Pacific White-sided Dolphin is taken directly and incidentally in small numbers in fisheries throughout its range. From 1985 through 1987 a total of 14 (four of which were released alive) were caught in an experimental drifnet fishery for Flying Squid (*Ommastrephes bartrami*) in offshore Canadian waters, the second most frequent incidentally taken cetacean. Small numbers are also taken incidentally in net fisheries in British Columbia, but a lack of comprehensive recording of net-induced mortality makes determination of the extent of this catch or its impact on populations difficult. Based on sighting records, the number of Pacific White-sided Dolphins in Canadian waters is probably high. Exact determination of status, especially population trends, cannot be made at this time. With the presumed lack of serious threats, however, and until further studies elucidate population numbers and trends, the Pacific White-sided Dolphin should be considered not in jeopardy and therefore not in any COSEWIC category.

Le Dauphin à flancs blancs du Pacifique (*Lagenorhynchus obliquidens*) semble fréquenter en grand nombre et de façon permanente les eaux profondes au large de la côte ouest du Canada et effectuer de fréquentes incursions dans les eaux côtières. Le présent rapport expose de manière générale les particularités biologiques de cette espèce, sa situation, particulièrement au Canada, et les mesures de gestion dont elle fait l'objet. Les auteurs y font état de 156 observations qui ont eu lieu à l'intérieur de la zone économique élargie canadienne de 320 kilomètres (200 milles). Le nombre d'individus observés varie d'un à 4000; la taille moyenne, médiane et le monde des troupeaux est de 62, 15 et 6 respectivement. Ces observations ont eu lieu dans des eaux de 10 à 2000 brasses de profondeur, avec des valeurs moyenne, médiane et mondale de 617, 400 et 100 brasses respectivement. La température de l'eau en surface mesurée à 73 points d'observation variait entre 6 et 17 degrés Celsius, avec des valeurs moyenne, médiane et modale de 12, 13 et 15 degrés Celsius respectivement. Dans toute son aire de répartition, le Dauphin à flancs blancs du Pacifique est capturé directement et accidentellement, en petit nombre, par des pêcheurs. De 1985 à 1987, dans le cadre d'une pêche expérimentale de l'Encornet géant (*Ommastrephes bartrami*) à l'aide de filets maillants dérivants dans les eaux hauturières canadiennes, ce cétacé occupait la deuxième place en importance parmi les prises accidentelles, soit un total de 14 prises (dont quatre ont été relâchés vivant). On sait qu'il s'en capture également accidentellement en petits nombres dans la pêche au filet en Colombie-Britannique; malheureusement, faute de statistiques exhaustives sur la mortalité par prises accidentelles, il serait hasardeux de vouloir se prononcer sur l'effet de ces prises sur les populations. D'après les observations consignées, on peut supposer qu'un grand nombre de Dauphins à flancs blancs du Pacifique fréquentent les eaux canadiennes; il est néanmoins impossible de déterminer avec exactitude la situation de ces populations, et encore moins les tendances démographiques. Cependant, comme cette espèce ne semble pas gravement menacée par quelque facteur que ce soit, en attendant que des études nous éclairent sur les populations et les tendances démographiques, elle ne doit pas être considérée comme menacée et ne doit donc pas être inscrite dans aucune des catégories du CSEMDC.

Key Words: Pacific White-sided Dolphin, Dauphin à flancs blancs du Pacifique, *Lagenorhynchus obliquidens*, Canada, North Pacific, status, cetacean.

This report reviews the biology and management of the Pacific White-sided Dolphin, *Lagenorhynchus obliquidens* Gill 1865, with particular reference to its status in Canada. This review has been undertaken by request of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), Fish and Marine Mammal Subcommittee. All marine mammals

*Report accepted by COSEWIC 11 April 1990 — no status designation required

have been included in the mandate of this committee, regardless of their status, because of their listing under CITES, the Convention on International Trade in Endangered Species of Wild Fauna and Flora. CITES has taken a conservative approach to management by listing all cetaceans under either Appendix I or II, due to the inability of non-specialists to distinguish various cetacean species, or parts thereof, in international trade.

The Pacific White-sided Dolphin reaches maximum lengths of at least 2.5 m and weights of up to 181 kg (Everitt et al. 1980; Walker et al. 1986). Leatherwood et al. (1982) and Walker et al. (1986) provide detailed descriptions of this small toothed whale. The most apparent physical characteristic of the Pacific White-sided Dolphin, seen when surfacing, is the tall, usually falcate dorsal fin which is bicoloured; the forward third dark and the trailing two-thirds light. The dorsal fin varies considerably in size, and ranges in shape from falcate and sharply pointed to lobate and more rounded on the tip. Such differences may be age-related (Walker et al. 1986). The basic body colour is black dorsally, grey and black laterally and white ventrally. A pair of light-coloured stripes extend along each side from the head, upwards towards and past the dorsal fin, and down, ending in a light grey flank patch (Figure 1). The forehead and the sides of the body in front of the dorsal fin are grey. A thin dark band separates the grey and black zones of the side from the white ventrum. The small dark beak is distinctly marked off from the head. The pectoral fins are long, and are occasionally similar to the dorsal fin in coloration, being dark on the leading edge and light posteriorly. The dark flukes have a concave trailing edge and a median notch. The teeth are small, pointed and slightly recurved. Numbers of teeth range between 21 to 33 in each side of the upper and lower jaws (Leatherwood et al. 1982; Leatherwood and Reeves 1983; Minasian et al. 1984).

Several colour variations have been recorded from Pacific White-sided Dolphins. These include largely all-white individuals (Figure 2), and those with an unusual white stripe along the upper side of the body (Figure 3) [Brown and Norris 1956; Walker et al. 1986; Black 1989]. All-black individuals have also been observed (S. Leatherwood, San Diego National History Museum, San Diego, California, personal communication). It is not known what implications these colour variations have, if any, on stock differentiation (Leatherwood et al. 1982). Walker et al. (1986) found a marked reduction in cranial size in Pacific White-sided Dolphins found above 37°N compared to those found below 32°N. Based on cranial morphometrics they suggest the existence of two populations in the northeastern Pacific. Leatherwood and Reeves (1983) note that two stocks, northwestern and northeastern Pacific, separated by an area of low density along the south side of the central Aleutians, have been proposed. Sleptsov (1955) described *Lagenorhynchus ognevi* from the North Pacific, but this species designation is now thought to be invalid, with the diagnostic characters well within the limits of variation found within *Lagenorhynchus obliquidens* (Tomilin 1957; Walker et al. 1986). In the older literature the Pacific White-sided Dolphin is called the Pacific Striped Dolphin or the Pacific Striped Porpoise (Osgood 1901; Cowan and Guiguet 1965).

FIGURE 1. Normal coloration of the Pacific White-sided Dolphin. Photo by Richard Stroud, U.S. Fish and Wildlife Service

FIGURE 2. Anomalous-coloured white individual three miles east of Pedro Point, Santa Cruz Island, California, November 1967. There has been no verification that the white form is albinism. Photo by Steve Leatherwood/Norbert Brilschmidt.

Distribution

The Pacific White-sided Dolphin is restricted to the temperate waters of the North Pacific Ocean (Figure 4). Canadian waters are in the central portion of their coastal range. Their presence has been recorded as far north as Amchitka Island in the Aleutians and throughout the Gulf of Alaska (Leatherwood et al. 1982). In the eastern Pacific the southern portion of their range extends around Baja California into the Gulf of California (Aurioles et al. 1988). They are found in the western North Pacific from the Kurile and Commander Islands to Taiwan (Walker et al. 1986).

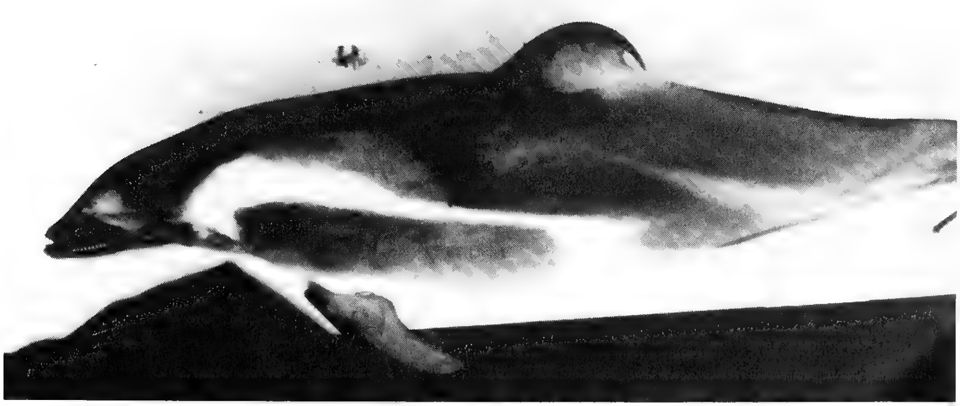

FIGURE 3. Anomalous-coloured individual with white stripe extending laterally from below the dorsal fin to above the eye. Photo by Richard Stroud.

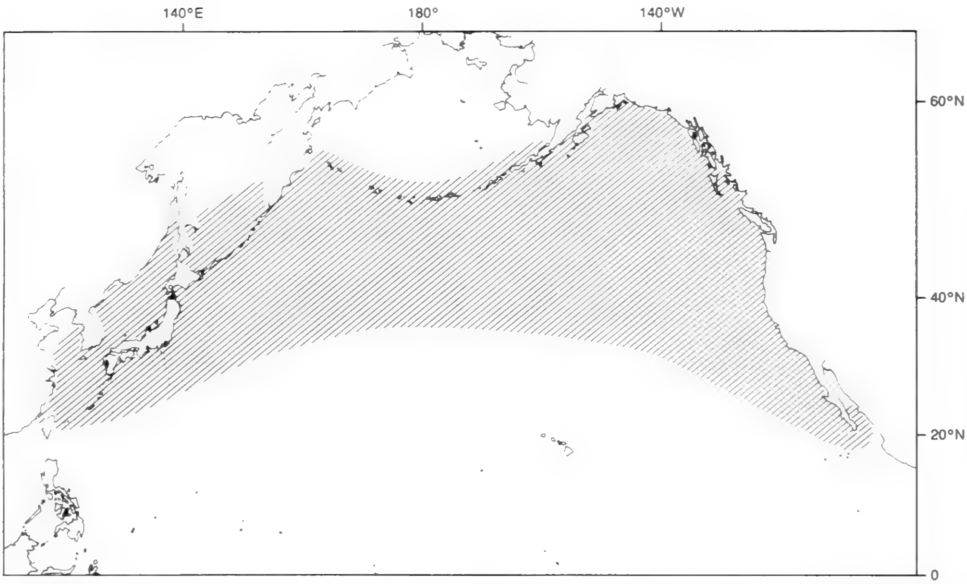

FIGURE 4. Approximate range of the Pacific White-sided Dolphin. Effort in many areas was minimal so actual range may be greater than shown.

Other than a few reports of sightings or strandings, no scientific studies have been undertaken on this species in British Columbia. Although they are generally considered abundant in British Columbia waters, only 23 detailed records have actually been published from the Canadian 320 km (200 mi) extended economic zone (EEZ). Because of this lack of published information on this species in British Columbia waters, we have made an attempt to collect as many published and unpublished records as possible to October 1988, and to analyze these records for seasonal distribution and abundance, herd size, habitat preferences (depths, temperature), and interspecific associations. Since that time we have obtained additional records from prior to 1988, but they are not included or analyzed here. Analyses of records available through 1979 for the entire eastern Pacific were presented by Leatherwood et al. (1984). Records presented here from the United States National Marine Mammal Laboratory (NMML) Platforms of Opportunity Program prior to 1979 were used by Leatherwood et al. (1984), but were not presented in detail. Since there has been no quantification of effort, absolute determination of trends in distribution or seasonal abundance cannot be made, and only a qualitative interpretation of the records is presented here.

The first recorded sighting of a Pacific White-sided Dolphin in British Columbia comes from Osgood (1901), who reports on "a porpoise supposed to be this species" in Hecate Strait. A skull found off the west coast of Vancouver Island in 1943 is reported by Cowan and Guiguet (1952) to be the first specimen record from Canadian waters, although Scheffer and Slipp (1948) describe the collection of a single animal from a school off Race Rocks Lighthouse, at the southern tip of Vancouver Island, in 1936. Pike and MacAskie (1969) list 35 sightings off British Columbia, 15 of which are outside the EEZ and so are not included in this analysis. The inclusion in this paper of records from adjacent United States and international waters might give a more accurate account of this species' biology, but for convenience of record collection and presentation, only Canadian records are presented here.

Recent records from within the Canadian EEZ have been acquired from several sources. These records and previously published records, totalling 156, are presented in Table 1 (*see also* Figure 5). Additional records are available that are most likely this species, but positive identification could not be made, so they are not included here. There are few cetacean sighting records compiled from offshore waters in British Columbia by Canadian researchers or authorities. A lack of experienced observers also contributes to the poor knowledge of the distributions and abundance of small or offshore species. As well, considering that there is no accepted central repository for cetacean records in British Columbia, it is likely that many more records exist than are reported here.

TABLE 1. Records of the Pacific White-sided Dolphin in British Columbia.

Date	Location[a]	Number	Source[b]	Type[c]
17 September 1936	off Race Rocks	1	1	1
pre-June 1943	Estevan Point	1	2	2
pre-October 1943	Port Hardy	1	3	3
01 June 1956	48°00′N,127°30′W	4	3	4
24 March 1958	47°48′N,128°00′W	20-30	3	4
12 March 1959	off Triange Island	5	3	1
16 June 1959	53°30′N,133°40′W	1000+	4	4
04 August 1959	48°00′N,128°00′W	100	3	4
08 January 1960	Fitzhugh Sound	50-100	3	4
10 March 1960	Fitzhugh Sound	100	3	4
21 June 1960	Fitzhugh Sound	3	3	4
20 July 1960	51°48′N,130°39′W	30-40	3	4
01 October 1960	Goletas Channel	200-300	3	4
06 November 1960	Port Hardy	200	3	4
12 December 1960	Fitzhugh Sound	200-300	3	4
26 January 1961	51°45′N,128°00′W	10	5	4
27 January 1961	52°13′N,128°45′W	5	5	4
09 February 1961	54°16′N,130°28′W	6	5	4
19 March 1961	51°45′N,127°56′W	15	5	4
14 May 1961	Goletas Channel	30	3	4
17 May 1961	Queen Charlotte St.	10	3	4
24 May 1961	Goletas Channel	6	3	4
15 June 1961	48°27′N,126°30′W	30	3	4
06 August 1961	Port Hardy	8	3	4
07 March 1962	52°N,128°W	100	3	4
21 June 1963	49°26′N,130°34′W	4	5	4
21 June 1963	49°26′N,130°31′W	1	5	4
15 May 1964	51°N, 131°W	100	3	4
02 August 1964	49°N,127°W	8	3	4
25 January 1967	49°03′N,127°13′W	5	5	4
25 January 1967	49°01′N,128°35′W	4	5	4
03 February 1967	48°26′N,126°16′W	2	5	4
03 February 1967	48°26′N,126°20′W	6	5	4
14 February 1969	Pat Bay, Victoria	1	6	2
09 May 1970	48°34′N,125°49′W	1	5	4
20 April 1972	48°27′N,125°58′W	1000	5	4
02 May 1972	48°25′N,125°55′W	30	5	4
02 May 1972	48°30′N,126°03′W	200	5	4
03 May 1972	48°26′N,125°59′W	200	5	4
30 August 1973	48°28′N,126°44′W	4	5	4
02 September 1973	48°20′N,128°42′W	17	5	4
10 March 1974	52°23′N,128°29′W	100	5	4
09 May 1974	51°23′N,127°51′W	150	5	4
15 March 1975	51°52′N,127°56′W	100	5	4
04 August 1975	53°35′N,133°47′W	20	5	4
03 April 1976	52°21′N,128°31′W	100	5	4
18 October 1977	49°41′N,128°04′W	250	5	4
12 February 1978	51°50′N,127°55′W	30	5	4
08 July 1978	51°22′N,131°23′W	6	5	4
09 July 1978	49°10′N,127°00′W	20	5	4
11 July 1978	48°32′N,126°50′W	100	5	4
11 July 1978	49°13′N,128°30′W	15	5	4
11 July 1978	49°33′N,129°19′W	6	5	4
11 July 1978	49°58′N,130°21′W	15	5	4
11 July 1978	49°58′N,130°21′W	55	5	4
15 September 1978	49°49′N,128°22′W	25	5	4
18 September 1978	50°13′N,128°10′W	200	5	4
19 November 1978	49°58′N,127°52′W	350	5	4
03 February 1979	49°18′N,127°22′W	4	5	4
13 May 1979	51°20′N,131°28′W	2	5	4

TABLE 1. *Continued.*

Date	Location[a]	Number	Source[b]	Type[c]
23 June 1979	Francis Is.	1	6	2
30 June 1979	51°45'N,129°02'W	60	5	4
16 August 1979	51°01'N,129°57'W	15	5	4
06 September 1979	54°00'N,131°00'W	75	5	4
18 November 1979	52°24'N,128°26'W	30	5	4
18 January 1980	52°35'N,128°28'W	100	5	4
29 March 1980	51°13'N,131°20'W	6	5	4
30 March 1980	49°27'N,127°46'W	80	5	4
02 May 1980	53°05'N,128°33'W	100	5	4
02 May 1980	52°24'N,128°30'W	2	5	4
02 May 1980	52°23'N,128°30'W	8	5	4
19 June 1980	51°06'N,130°07'W	6	5	4
25 July 1980	50°29'N,128°50'W	8	5	4
25 July 1980	50°25'N,128°46'W	5	5	4
25 July 1980	50°05'N,128°18'W	6	5	4
25 July 1980	50°02'N,128°15'W	75	5	4
02 August 1981	49°45'N,134°05'W	20	5	4
20 August 1981	Ramsay Is., QCI	1	6	2
10 November 1981	51°59'N,127°56'W	200	5	4
29 November 1981	52°04'N,127°56'W	35	5	4
17 April 1982	53°17'N,128°53'W	2	5	4
22 August 1982	50°56'N,132°09'W	200	5	4
23 August 1982	48°46'N,126°31'W	75	5	4
19 November 1982	48°38'N,126°12'W	4	5	4
25 February 1983	53°14'N,128°48'W	13	5	4
02 March 1983	Vancouver Harbour	1	7	2, 5
16 April 1983	52°47'N,128°32'W	10	5	4
13 May 1983	51°43'N,127°55'W	40	5	4
17 June 1983	Long Beach	1	6	2
22 June 1983	49°20'N,127°23'W	25	5	4
19 July 1983	48°17'N,126°15'W	50	5	4
19 July 1983	48°19'N,126°20'W	3	5	4
19 July 1983	48°19'N,126°21'W	3	5	4
20 July 1983	50°45'N,132°27'W	150	5	4
20 July 1983	51°03'N,133°36'W	1	5	4
29 July 1983	49°13'N,127°17'W	10	5	4
29 July 1983	49°23'N,127°46'W	3	5	4
17 August 1983	48°35'N,126°56'W	6	5	4
18 August 1983	48°39'N,127°40'W	10	5	4
18 August 1983	48°40'N,127°49'W	7	5	4
18 August 1983	48°48'N,129°05'W	11	5	4
22 August 1983	49°13'N,129°59'W	5	5	4
10 October 1983	50°40'N,129°27'W	200	5	4
13 October 1983	52°32'N,133°46'W	80	5	4
14 October 1983	50°30'N,129°03'W	3	5	4
03 February 1984	52°11'N,128°29'W	20	5	4
03 February 1984	53°18'N,129°09'W	3	5	4
14 March 1984	52°19'N,129°06'W	10	5	4
28 March 1984	49°02'N,125°41'W	3	5	4
01 April 1984	48°26'N,128°43'W	4	5	4
11 April 1984	52°34'N,128°28'W	2	5	4
11 April 1984	53°25'N,129°24'W	6	5	4
03 May 1984	52°36'N,128°29'W	100	5	4
19 June 1984	51°26'N,134°51'W	6	5	4
19 February 1985	48°24'N,127°53'W	3	5	4
13 April 1985	53°52'N,130°04'W	40	5	4
01 June 1985	52°40'N,128°32'W	4	5	4
22 July 1985	47°35'N,130°48'W	1	8	6
18 August 1985	49°26'N,131°39'W	1	8	7
12 November 1985	51°5[illegible]'N,127°56'W	30	5	4

TABLE 1. *Concluded.*

Date	Location[a]	Number	Source[b]	Type[c]
26 January 1986	54°27′N,130°40′W	6	5	4
20 February 1986	50°48′N,127°33′W	3	5	4
26 April 1986	48°20′N,125°55′W	6	5	4
13 June 1986	48°17′N,126°10′W	8	5	4
27 July 1986	48°23′N,129°16′W	1	8	7
29 July 1986	47°50′N,130°00′W	1	8	7
22 August 1986	51°37′N,136°17′W	1	8	7
14 October 1986	49°14′N,128°03′W	16	5	4
20 October 1986	51°44′N,127°55′W	400	5	4
23 October 1986	Round Is. (Pt. Hardy)	1	6	7
00 November 1986	Campbell River	> 300	9	4
13 November 1986	50°10′N,125°21′W	5	5	4
13 November 1986	50°15′N,125°23′W	30	5	4
19 July 1987	49°05′N,130°38′W	2	8	7
25 July 1987	48°30′N,129°16′W	20-25	8[d]	4
25 July 1987	48°30′N,129°16′W	2	8[d]	7
25 July 1987	48°30′N,129°16′W	3	8[d]	6
27 July 1987	48°29′N,129°22′W	1	8	7
29 July 1987	48°30′N,129°34′W	1	8	7
11 April 1988	53°08′N,128°33′W	100	9	4
25 May 1988	48°26′N,126°12′W	15	10	4
18 June 1988	48°45′N,126°20′W	25	10	4
13 August 1988	49°16′N,127°36′W	100	10	4
19 August 1988	48°25′N,126°W	1	11	7
21 August 1988	52°22′N,130°59′W	12	9	4
21 August 1988	52°22′N,130°58′W	11	9	4
28 August 1988	49°06′N,126°54′W	15	10	4
30 August 1988	48°05′N,128°10′W	25	10	4
30 August 1988	48°07′N,128°16′W	3	10	4
30 August 1988	West Coast of Queen Charlotte Islands	6	9	4
29 September 1988	Port Hardy	1	11	7
30 September 1988	48°23′N,126°07′W	22	10	4
30 September 1988	48°24′N,126°13′W	12	10	4
30 September 1988	48°24′N,126°16′W	2	10	4
02 October 1988	48°20′N,125°28′W	1	10	4
30 October 1988	48°07′N,125°51′W	3	10	4

[a]Location of previously published records as presented in the original source.
[b]Source of Record: (1) Scheffer and Slipp 1948; (2) Cowan and Guiguet 1952; (3) Pike and MacAskie 1969; (4) Pike 1960; (5) NMML Platforms of Opportunity Program; (6) Royal B.C. Museum records; (7) Vancouver Public Aquarium; (8) G.D. Heritage, Pacific Biological Station, Nanaimo, B.C.; (9) B.C. Marine Mammal Sighting Program; (10) K. Morgan, Canadian Wildlife Service, Sidney, B.C.; (11) Stacey et al. 1989.
[c]Type of Record: (1) Collection; (2) Stranding; (3) Remains in Indian Midden; (4) Sighting; (5) Capture for Captivity; (6) Incidental Catch, Released Alive; (7) Incidental Catch, died.
[d]Although this occurrence is considered as three records, for the purposes of depth and temperature analysis it is used once.

Over 50% of the records presented are from 1980 through 1988. However, it cannot be determined whether this difference is due to an actual change in abundance, or just to an increase in recording effort. Although Pacific White-sided Dolphins do not appear to be particularly common in inshore waters, inshore records from British Columbia waters have been reported in nine of the last 10 years. Some authors have reported that they occur regularly in Juan de Fuca Strait and the Strait of Georgia (Cowan and Guiguet 1965; Osborne et al. 1988), but records compiled do not support this suggestion. However, due to limited research in this area at any time, it is likely that they may be more common than reported.

Protection

International

Regulation of international trade between members of the Convention on International Trade in Endangered Species of Wild Fauna and Flora 1973 (CITES) and between non-members

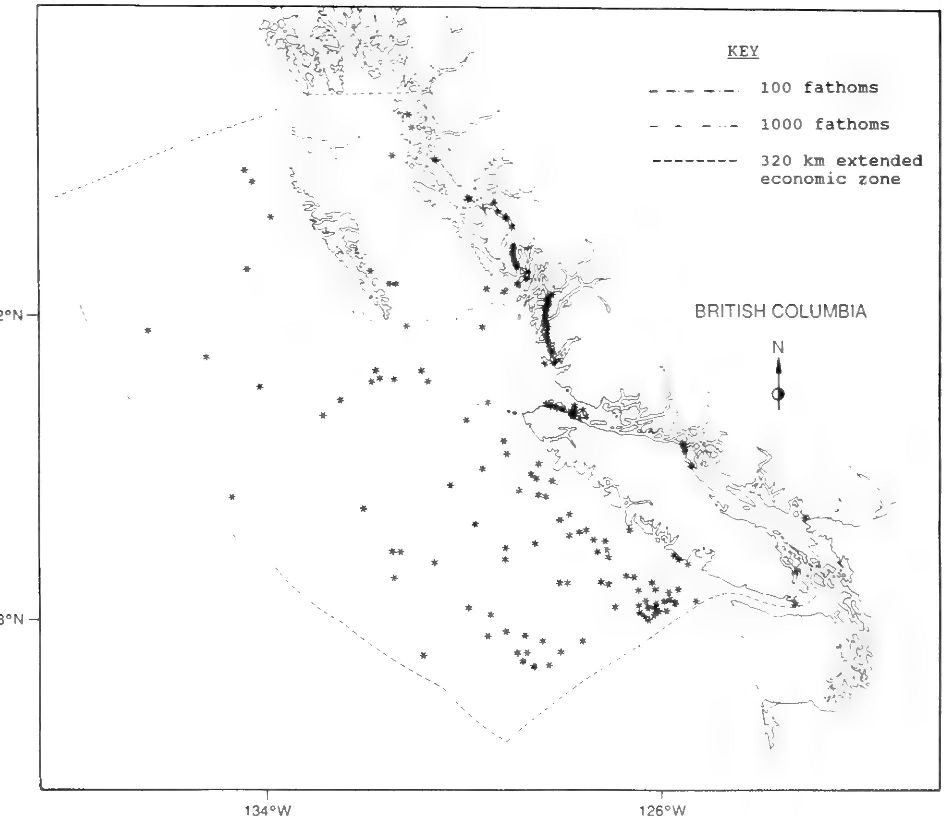

FIGURE 5. Records of the Pacific White-sided Dolphin in the Canadian 320 km extended economic zone. See Table 1 for details of date, location, number, source and type of record. Records from immediately adjacent U.S. or offshore waters are not shown.

and Convention members, has been established by listing the Pacific White-sided Dolphin under Appendix II of the Convention (*see* Birnie 1982). The International Whaling Commission (IWC) regulates the taking of whales in accordance with the current Schedule provisions, but whether this Commission's mandate covers the Pacific White-sided Dolphin is unclear, as members of this Commission are divided to whether "whale" refers to all cetaceans or only to some species (Klinowska 1987).

National

Canada: The 1982 Cetacean Protection Regulations of the Fisheries Act of Canada of 1867 (as amended to date) provide protection for this and other species of cetaceans, for all but aboriginal hunting. "Hunting" is defined as "to chase, shoot at, harpoon, take, kill, attempt to take or kill, or to harass cetaceans in any manner", and can only be undertaken under licence.

United States: All cetaceans are protected under the Marine Mammal Protection Act of 1972, as well as through the Packwood-Magnuson Amendment of the Fisheries and Conservation Act and the Pelly Amendment of the Fisherman's Protective Act.

Population Size(s) and Trends

Leatherwood et al. (1984) noted that the Pacific White-sided Dolphin may be the most abundant delphinid in the temperate eastern North Pacific, although no accurate population estimate is possible with the currently available data. One population estimate presented by the U.S. Department of Commerce (1988) was of 30 000 to 50 000 animals for the eastern Pacific, not including Alaskan waters. Nishiwaki (1972) gave an estimate of 30 000 to 50 000 animals from the waters around Japan. The number of records has greatly increased in Canadian waters in recent years, but with no quantification of effort it is unknown whether this is due to an actual increase in population numbers, a change in distribution, or an increase in effort.

Habitat

Pacific White-sided Dolphins occur both on the continental shelf and further offshore (Leatherwood et al. 1984). Fiscus and Niggol (1965) note that of 135 sightings, few were seen inside the 100 fathom or outside the 1000 fathom contour. Black (1989) records sightings in depths ranging from 100 m (*ca* 55 fathoms) to 3000 m (*ca* 1640 fathoms) in Monterey Bay, California. Water depths associated with 141 records in British Columbia ranged from 10 to 2000 fathoms, with a mean, median and modal depth of 617, 400 and 100 fathoms respectively.

Black (1989) found that Pacific White-sided Dolphins in Monterey Bay, California, were sighted in waters ranging from 12.1-19.0°C. Sea surface temperatures of 73 records from British Columbia waters were obtained from the NMML Platforms of Opportunity Program, and from the experimental Flying Squid (*Ommastrephers bartrami*) fishery (Jamieson and Heritage 1987, 1988). Temperatures range from 6° to 17°C, with a mean, median and modal temperature of 12°, 13° and 15°C respectively.

General Biology

Reproduction

Figures available for reproductive parameters have been quite variable, possibly due to the presence of two separate populations (Walker et al. 1986). No estimates of calving interval or annual pregnancy rates are available. Estimates of gestation range from 10 to 12 months (Harrison 1969; Perrin and Reilly 1984; Kajimura and Loughlin 1988). Sightings and foetal records indicate that mating and calving may occur from late spring through autumn, although this is based on few data (Brown and Norris 1956; Tomilin 1957; Norris and Prescott 1961). Estimates of length at birth range from 0.8 to 1.24 m (Leatherwood et al. 1982; Perrin and Reilly 1984).

Osborne et al. (1988) note that sexual maturity is attained between six and 10 years of age. This species attains sexual maturity at lengths ranging from 1.67 to 2.13 m in the male and 1.70 to 2.16 m in the female, with an average length of sexually mature animals of 1.90 m for males and 1.92 m for females (Perrin and Reilly 1984; Cowan et al. 1986). Minimum weight of a mature testis is approximately 170 g (Kasuya and Izumizawa 1981), while maximum reported weight is 559 g, although these weights are from animals from the western and eastern Pacific respectively (Perrin and Reilly 1984). Ovulation rate has been noted as high compared to other delphinids (Perrin and Reilly 1984). Longevity has not been determined, but up to 46 growth layer groups in teeth have been reported, with the assumption made that one growth layer group represents one year (Walker et al. 1986).

Species Movement

Leatherwood et al. (1984) note that Pacific White-sided Dolphins exhibit typical northern and offshore movements in spring and summer and southern inshore movements in fall and winter. They are year-round residents in some areas (Leatherwood et al. 1982). A radio-tagged individual reported by Leatherwood and Evans (1979) showed little net movement over a 45-day period off the California coast. Wilke et al. (1953) report migrations along the Japanese coast in relation to fish and squid abundance.

In British Columbia waters there are inshore records from all months except July, and offshore records from all months except December. The largest number of records have been collected in July and August (26 and 25 respectively). Since recording effort is highest and sighting conditions are also probably best during these two months, this does not necessarily reflect a peak in abundance. The largest number of records in inshore waters are from January through May, and from November. Considering the small number of records in inshore waters in June through October, the large number of records in November and in January through May might reflect movements into inshore waters in winter and spring.

Behaviour

Pacific White-sided Dolphins travel in congregations that are among the largest of any dolphin, sometimes in groups of several thousand (Leatherwood et al. 1982). Maximum group size reported by Leatherwood et al. (1984) was of 6000 individuals, with a mean of 88 individuals per group. They found herd size in the eastern North Pacific to be larger in southern and northern areas of the Pacific White-sided Dolphins' range than in the central area. Analysis of group size from 149 sighting records reported here indicates that mean group size is 62, with a range of one to 1000. The median group size is 15 and the mode is six individuals, while 100 is the second most frequently reported group size.

Pacific White-sided Dolphins are opportunistic feeders, preying primarily on cephalopods and small schooling fishes from the epipelagic (0 to 200 m, *ca* 109 fathoms) and mesopelagic (200 to 1000 m, *ca* 109 to 547 fathoms) zones (Kajimura et al. 1980; Stroud et al. 1981). These authors also note that feeding most likely occurs at night and in the morning. Fitch and Brownell (1968) inferred from prey habits that the diving depth is at least 120 m (*ca* 66 fathoms). Stomach volume has been reported as 1600 cc (Fiscus and Niggol 1965).

Stroud et al. (1981) review feeding habits, and note that prey includes several commercially important species, such as salmon (*Oncorhynchus* sp.), Northern Anchovy (*Engraulis mordax*), Hake (*Merluccius productus*), and Market Squid (*Loligo opalescens*). In Washington waters, squid from stomach contents represented seven families (Loliginidae, Enoploteuthidae, Octopoteuthidae, Onychototeuthidae, Gonatidae, Chiroteuthidae, and Cranchiidae). Jellyfish have been recorded from the stomach contents of at least one individual (Scheffer 1953).

Reports of interspecific associations are frequent; Black (1989) reports that of 224 schools of Pacific White-sided Dolphins observed in Monterey Bay, California, interspecific associations occurred 50% of the time. A summary of species recorded in association with Pacific White-sided Dolphins is presented in Table 2. Associations have been noted with seven species of odontocetes, three species of mysticetes and two species of pinnipeds, as well as with sea birds. Interspecific associations have only been noted in four records from British Columbia waters, three with Northern Right Whale Dolphins (*Lissodelphis borealis*) and a fourth with both Northern Right Whale Dolphins and Short-finned Pilot Whales (*Globicephala macrorhynchus*). Associations with Northern Right Whale Dolphins and Common Dolphins (*Delphinus delphis*) were most frequently reported (Black 1988). The low number of associations with these two species in British Columbia may be due to a low number of sightings of them here. There are only 17 known occurrences of Northern Right Whale Dolphins in British Columbia waters (Baird and Stacey 1991) and only one record of a Common Dolphin in British Columbia (Guiguet 1954). Although discrepancies in record reporting may partially account for the small numbers of interspecific associations, the difference in the proportion of associations from that found by Black (1988, 1989) appears substantial.

Pacific White-sided Dolphins are often acrobatic, leaping clear of the water (Figure 6), and doing bellyflops and somersaults. They have become accomplished performers in captivity, are displayed in aquaria in Canada, Japan, New Zealand, and the United States (Defran and Pryor 1980). Epimeletic (care-giving) behaviour has been reported (Caldwell and Caldwell 1966; Kasuya and Miyazaki 1976). Pacific White-sided Dolphins are avid bow-riders, and have been seen to displace Common Dolphins to obtain the best position while bow-riding (Leatherwood et al. 1982). Observations of this type suggest intergeneric hierarchies (Leatherwood and Reeves 1978).

Limiting Factors

Fourteen Pacific White-sided Dolphins were incidentally caught in an experimental Flying Squid driftnet fishery in Canadian waters from 1985 through 1987, resulting in 10 known mortalities (Jamieson and Heritage 1987, 1988). This was the second most frequent incidentally taken cetacean in this fishery, which has now been discontinued. Small numbers have also been caught incidentally in coastal net fisheries in British Columbia (Stacey et al. 1989; Stacey et al. 1990; Baird et al. 1991), but exact determination of these numbers is virtually impossible since commercial vessels are not encouraged or required to report incidental catches. Some are also taken incidentally in tuna, anchovy and salmon fisheries (Leatherwood et al. 1984). Wilke (1953) reports large numbers of Pacific White-sided Dolphins

TABLE 2. Species recorded in association with Pacific White-sided Dolphins.

Species	Source[1]
Northern Right Whale Dolphin, *Lissodelphis borealis*	a
Risso's Dolphin, *Grampus griseus*	a
Striped Dolphin, *Stenella coeruleoalba*	b
Common Dolphin, *Delphinus delphis*	c
Short-finned Pilot Whale, *Globicephala macrorhynchus*	d
Bottlenose Dolphin, *Tursiops truncatus*	e
Dall's Porpoise, *Phocoenoides dalli*	f
Humpback Whale, *Megaptera novaeangliae*	f
Sei Whale, *Balaenoptera borealis*	f
Grey Whale, *Eschrichtius robustus*	g
California Sea Lion, *Zalophus californianus*	e
Northern Fur Seal, *Callorhinus ursinus*	a
Sea Birds	g

[1]Source: (a) Pike 1960; (b) Minasian et al. 1984; (c) Brown and Norris 1956; (d) Norris and Prescott 1961; (e) Leatherwood and Walker 1979; (f) Brownell 1964; (g) Leatherwood 1974. Only a single early source is presented, even if noted by other authors.

FIGURE 6. Pacific White-sided Dolphins racing alongside a Japanese fishing vessel. Photo by David Ambrose, National Marine Fisheries Service.

taken off Japan in fisheries for dolphins and porpoises. Between 1979 and 1987 the number taken yearly off Japan has ranged from 2765 in 1984 to 37 in 1986, reflecting both direct and incidental catches (IWC 1986, 1988). More than 80 individuals were live-captured for display or research between 1966 and 1979 (Leatherwood et al. 1984). Accidental hooking on fishing lines has been reported (Norris and Prescott 1961).

Hoyt (1984) refers to predation on Pacific White-sided Dolphins by Killer Whales (*Orcinus orca*) in Nishiwaki and Handa (1958), but examination of that reference does not specifically indicate predation. However, Wells et al. (1980) list Killer Whales as predators; a likely occurrence as the range of the Pacific White-sided Dolphin in inshore waters overlaps with concentrations of transient Killer Whales, which feed primarily on marine mammals. We are not aware of any reports of predation by large sharks, but this may occur; shark predation on other species of dolphins has been reported (Wood et al. 1970; Ross and Bass 1971).

Mass strandings of this species have not been reported in the literature, although mass strandings of the genus *Lagenorhynchus* are not uncommon (Sergeant 1982). Single strandings of individuals are most likely the result of pathological conditions. Cowan et al. (1986) describe pathologies from stranded animals, but the determination of the positive cause of death and the role of pathogens in mortality is difficult to ascertain. A variety of fungal, viral and bacterial disease agents have been reported from the Pacific White-sided Dolphin (Migaki et al. 1978; Dailey 1985). Parasites of the genus *Nasitrema* have been associated with brain lesions in an animal found disoriented in Vancouver Harbour as well as in stranded animals off California (Cowan et al. 1986; Lewis and Berry 1988). Other parasites documented include the nematodes *Crassicauda* sp. and *Anisakis* sp. (Cowan et al. 1986; Walker et al. 1986), and the cestodes *Phyllobothrium delphini, Monorygma grimaldii, Tetrabothrius* sp., and *Strobilocephalus triangularis* (Dailey and Walker 1978). Although not necessarily detrimental to individuals, ectocommensal barnacles *Xenobalanus globicipitus* and diatoms *Cocconeis ceticola* have been reported from this species (Norris and

Prescott 1961; Morejohn 1979). Mortality by choking on prey was reported for a single individual off California (Houck 1961).

High levels of pollutants have been reported from an individual that was held in captivity in New York [1023 ppm wet weight DDT, 147 ppm wet weight PCBs; Taruski et al. (1975)]. The cause of death of this individual was not given. The role of these pollutants in mortality is unknown; however, there is speculation that reproductive failures in both cetaceans and pinnipeds might be linked in some way to the effects of contamination by organochlorine residues (Addison 1989). High levels of organochlorines have been implicated in immunosuppression and high mortality in the St. Lawrence population of Beluga Whales, *Delphinapterus leucas*, (Martineau et al. 1987). The effects of industrial activities, such as oil and gas development and shipping on odontocetes are largely unknown but warrant further study (Hain et al. 1985).

Evaluation

The Pacific White-sided Dolphin is widespread and abundant throughout the North Pacific basin, and its population in Canadian waters does not appear to be particularly at risk, as long as incidental catches in Canadian fisheries can be curtailed. However, because of a lack of comprehensive population surveys, it is not possible to accurately determine population levels or trends, and a reassessment of status should be made after such studies have been undertaken. Radiotelemetry studies, aerial or ship-based surveys, monitoring of commercial net fisheries and maximizing information gained from stranded animals would all allow for greater understanding of the population status of this species in Canadian waters.

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Status of Risso's Dolphin, *Grampus griseus*, in Canada*

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Baird, Robin W., and Pam J. Stacey. 1991. Status of Risso's Dolphin, *Grampus griseus*, in Canada. Canadian Field-Naturalist 105(2): 233–242.

In the eastern North Pacific and the western North Atlantic, the Risso's Dolphin, *Grampus griseus*, reaches its northern limits in Canadian waters, and is rare in Canada. General biology, world-wide status and management are reviewed. Twenty-one records from Canadian waters are presented. Records from the Pacific coast of Canada are from throughout the year and show no seasonal trends. Little information is available on stocks or population estimates, but Risso's Dolphins are not uncommon worldwide. They are taken only in small numbers in whaling and incidentally in fisheries. The effects of longterm degradation of its environment and subsequent impact on its populations are potentially serious and should be monitored.

Le Marsouin gris, *Grampus griseus*, atteint la limite nord de son territoire dans les eaux canadiennes du Pacifique nord-est et de l'Atlantique nord-ouest. L'espèce est rare au Canada. Ce rapport examine la biologie générale de l'espèce ainsi que sa situation et sa gestion à l'échelle internationale et présente 21 observations dans les eaux canadiennes. Les observations dans les eaux canadiennes du Pacifique sont notées tous les mois de l'année et ne présentent aucune tendance saisonnière. Bien qu'il existe peu d'information sur les stocks et d'estimations des effectifs, le Marsouin gris n'est pas considéré comme rare à l'échelle mondiale. En dépit du fait que ce cétacé n'est capturé qu'en petit nombre à l'occasion de chasses à la baleine ou accidentellement dans les pêcheries, les effets à long terme de la dégradation de son environnement et ses répercussions sur ses effectifs pourraient être graves et doivent faire l'objet de surveillance.

Key Words: Risso's Dolphin, Marsouin gris, *Grampus griseus*, Canada, status, cetacean, North Pacific, North Atlantic.

This report provides an overview of the biology and management of the Risso's Dolphin, *Grampus griseus* (Cuvier 1812), and summarizes knowledge of its status, especially in Canadian waters.

The Risso's Dolphin (Figure 1) is a large dolphin with a stocky body that becomes slender behind the dorsal fin. It reaches a maximum length of 4 m (Mitchell 1975a) and weight of 500 kg. There is no evidence of size differences between the sexes (Leatherwood et al. 1982). The head is bulbous; the melon is much larger than that of most delphinids (Mead 1975); and there is no beak (Ross 1984). A shallow, V-shaped crease extends from the blowhole to the tip of the rostrum (Leatherwood et al. 1982). Two to seven pairs of teeth are present in the lower jaw (Ross 1984). One or two pairs of teeth may be found in the upper jaw (Fraser 1976). The lower jaw does not quite reach the tip of the snout (Tomilin 1957). The pectoral flippers are long, narrow and falcate. The dorsal fin is high, erect and falcate, and is set at the mid-point of the body (Ross 1984).

Risso's Dolphins are a uniform light gray at birth. They darken to a chocolate brown or black and appear to lighten again as they age (Leatherwood and Reeves 1983). Larger animals are typically cream-white or silver-grey, although the dorsal fin, flukes, and distal half of the flippers remain dark. The body is usually covered with linear scratch marks which may be from intraspecific encounters or from bites from the sharp-beaked squids on which Risso's Dolphins prey (Leatherwood et al. 1982). Their diet consists mainly of cephalopods and occasionally small fish (Tsutsumi et al. 1961; Mitchell 1975a).

Distribution

Until recently, little reliable information has been available on the distribution of many of the small cetaceans, including Risso's Dolphins. Risso's Dolphins have a world-wide distribution in tropical and warm temperate seas (Leatherwood et al. 1980). In the North Atlantic they have been reported from Newfoundland (Mitchell 1975a) and the Orkney Islands (Fraser 1974), south to the Lesser Antilles (Caldwell et al. 1971) and the Mediterranean area (Pilleri and Gihr 1969; Notarbartolo-di-Sciara 1987). In the South Atlantic they have been sighted as far south as Argentina (Goodall and Galeazzi 1987) and South

*Report accepted by COSEWIC 11 April 1990 — no status designation required.

FIGURE 1. Risso's Dolphin from the Queen Charlotte Islands. This animal live-stranded and died. Photo courtesy Gary Cardinal, Department of Fisheries and Oceans.

Africa (Barnard 1954). In the Pacific they are found as far north as the Gulf of Alaska (Braham 1983) and the Kurile Islands (Leatherwood and Reeves 1983), and as far south as central Chile (Aguayo 1975). They are distributed throughout the Indian Ocean (Kruse et al. *in press*) and are thought to be present throughout the Indo-Pacific area, occurring as far south as New Zealand and Australia (Mitchell 1975a). No information is available on the number and distribution of stocks (Mitchell 1975a).

A total of 21 records, totalling 15 separate occurrences from within the Canadian 320 km (200 mi) extended economic zone, have been located (Figure 2) and are summarized in Table 1. Details of 10 of these records have been previously published. F. D. Mitchell, Arctic Biological Station, also has records from the Canadian east

coast which will be reported in a future publication. Records from the west coast have been obtained from nine months of the year, showing no obvious seasonal trends. The five records listed in Table 1 from August and September 1978 in British Columbia were likely repeat sightings of a single group of individuals over a 13-day period (Baird et al. 1988). If these sightings are treated as a single occurrence then there are ten known occurrences in British Columbia waters, six of which are strandings. The November 1977 record from British Columbia waters listed in Table 1 appears to be the northernmost confirmed record from the eastern North Pacific, further north than those presented by Braham (1983). None of the east coast records are of strandings. Off the east coast all records have been from August or October, and all were obtained through the Cetacean and Turtle Assessment Program (CETAP). Other researchers working off the east coast of Canada have no records of this species (D. Gaskin, C. Haycock, S. Kraus, J. Lien, K. Lynch, J. Mead, R. Reeves, H. Whitehead, personal communications). Additional sightings and strandings have been reported in adjacent United States and international waters (Guiguet and Pike 1965; CETAP 1982; Braham 1983; Osborne et al. 1988).

Protection

International

Regulation of international trade between members of the Convention on International Trade in Endangered Species of Wild Fauna and Flora 1973 (CITES) and between non-members and Convention members, has been established by listing the Risso's Dolphin under Appendix II of the Convention (*see* Birnie 1982). The International Whaling Commission (IWC) regulates the taking of whales in accordance with the current Schedule provisions, but whether this regulation applies to Risso's Dolphins is unclear, as members of the Commission are divided as to whether the "whale" refers to all cetaceans, or only to some species (Klinowska 1987).

National

Canada: The 1982 Cetacean Protection Regulations of the Fisheries Act of Canada of 1867 (as amended to date) provide protection for this and other species of cetaceans for all but aboriginal hunting. "Hunting" is defined as "to chase, shoot at, harpoon, take, kill, attempt to take or kill, or to harass cetaceans in any manner", and can only be undertaken under licence.

United States: All cetaceans are protected under the Marine Mammal Protection Act of 1972, as well as through the Packwood-Magnuson Amendment of the Fisheries and Conservation Act and the Pelly Amendment of the Fisherman's Protective Act.

Population Sizes and Trends

Only one abundance estimate is available, and only for a fairly small defined area in the western North Atlantic. Hain et al. (1985) report that the abundance of animals in the northwestern Atlantic area from Cape Hatteras, North Carolina, to the Gulf of Maine, reaches a peak of an estimated 3543 (± 4350, 95% CI) individuals in summer and a low of 364 (± 1254, 95% CI) in winter. CETAP (1982) reported that in these waters the Risso's Dolphin was the fifth most commonly sighted small whale. The relative abundance per unit effort of Risso's Dolphin sightings decreased west of 70° W, in the waters approaching Nova Scotia (CETAP 1982). It appears that Risso's Dolphins are at the margin of their normal distribution in Canadian waters and have always been rare. Present population trends are unknown due to the scarcity of reported sightings and lack of distribution surveys.

Habitat

Risso's Dolphins are generally thought to be a widespread, warm-water pelagic species. Leatherwood et al. (1976) suggest that the species may not be as rare as the paucity of records indicates, as Risso's Dolphins usually remain seaward of normal boating traffic. In recent years a large number of data has been collected in connection with the incidental catch of delphinids in offshore fisheries. During a four-year study by Polacheck (1987) in the eastern tropical Pacific, high encounter rates of Risso's Dolphins tended to be mainly in relatively nearshore areas compared to pelagic offshore areas for some other small delphinids. Polacheck found that a concentration of Risso's Dolphins in association with Bottlenose Dolphins (*Tursiops truncatus*), Short-finned Pilot Whales (*Globicephala macrorhynchus*) and Common Dolphins (*Delphinus delphis*) existed near the Gulf of Panama. Hain et al. (1981) and Kenney and Winn (1986) identified the edge of the northeast United States continental shelf as a high-use area for Risso's Dolphins; their distribution pattern is generally along this edge from south of Nantucket, southwestward to Cape Hatteras (Hain et al. 1981). Summer extensions of the distribution eastward of Nantucket along Georges Bank occur, but there is no general tendency for them to move inshore onto the shelf proper (Hain et al. 1981). The average depth of Risso's Dolphin sightings was 1092 m, with a range of 20 to 4938 m which corresponded well with the concentration of sightings along the shelf edge during this study,

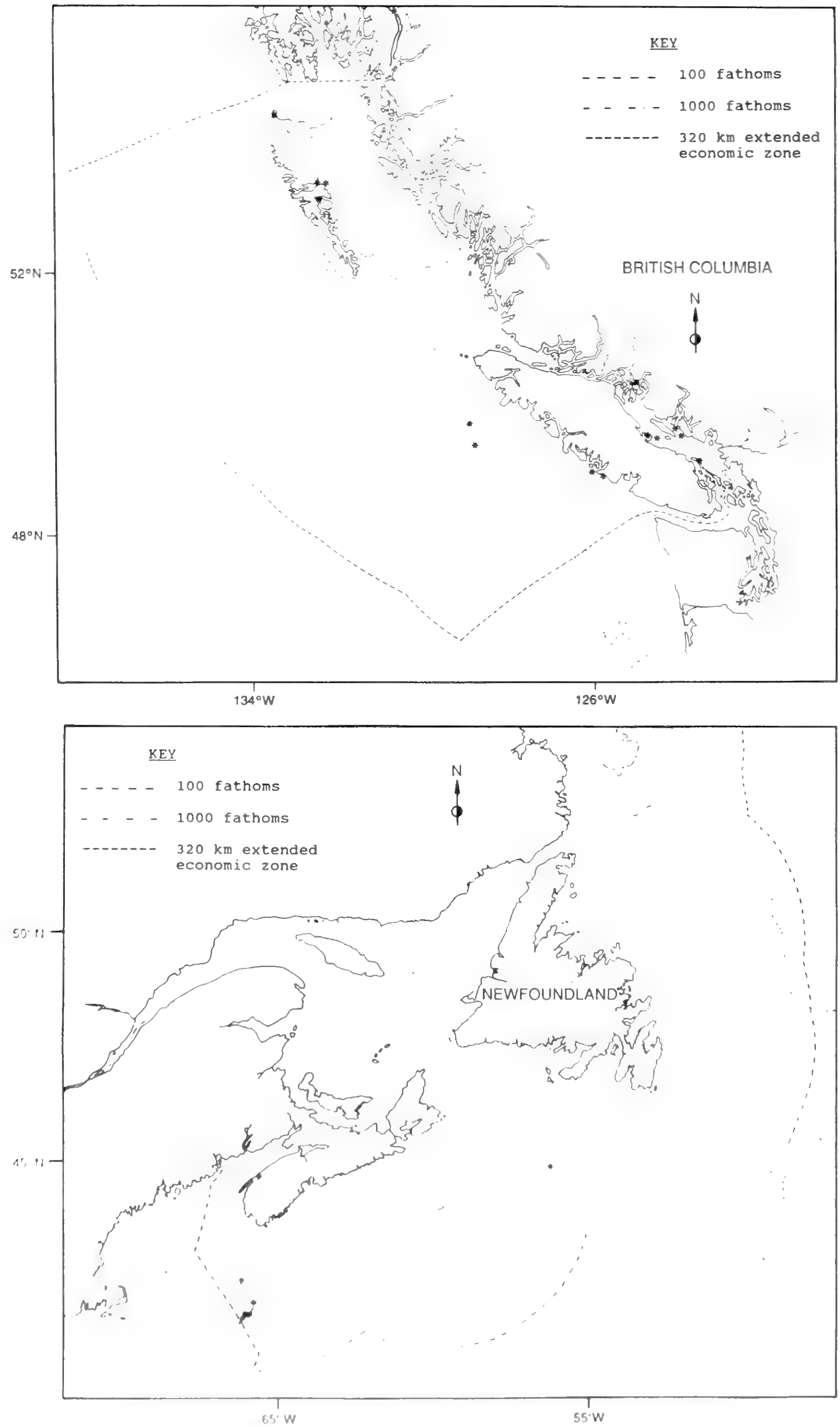

FIGURE 2. Known records of Risso's Dolphins in Canadian waters west coast (above) and east coast (below). See Table 1 for details.

TABLE 1. Records of Risso's Dolphins from Canadian waters.

Date	Location	Number	Type[a]	Source[b]
00 May 1964	50°20′N, 125°00′W	1	1	1
08 August 1968	45°00′N, 56°20′W	6	2	2
17 April 1970	49°10′N, 125°58′W	1	3	3
09 March 1976[c]	49°52′N, 128°37′W	2	2	4
09 March 1976[c]	49°50′N, 128°30′W	3	2	4
15 November 1977[d]	55°55′N, 130°02′W	1	4	5
27 March 1978	54°11′N, 133°01′W	14	2	6
13 August 1978[c]	49° N, 123° W	6	2	5
20 August 1978[c]	49°08′N, 123°40° W	6	2	7
27 August 1978[c]	49°29′N, 124°00′W	10-12	2	7
31 August 1978[c]	49°31′N, 124°40′W	5-8	2	7
02 September 1978[c]	49° N, 124′00′W	5-8	2	5
15 October 1978	41°38′N, 65°58′W	11	2	2
22 August 1979	41°17′N, 66°15′W	30	2	2
XXX 1979[e]	53°03′N, 132°00′W	1	3	8
25 August 1980[c]	41°20′N, 66°02′W	5	2	2
25 August 1980[c]	41°19′N, 66°01′W	18	2	2
15 October 1980	42°10′N, 66°19′W	7	2	2
26 January 1987	53°12′N, 131°48′W	1	3	7
06 March 1988[f]	53°15′N, 132°00′W	1	4	9
10 June 1989[g]	49°04′N, 125°46′W	1	3	10

[a]Type: 1. Direct take; 2. Sighting; 3. Stranding, found dead; 4. Live stranding, died.
[b]Source: 1. Guiguet and Pike 1965; 2. CETAP program; 3. Hatler 1971; 4. Braham 1983; 5. Vancouver Public Aquarium; 6. Reimchen 1980; 7. Baird et al. 1988; 8. M. Morris (Kallahin Expeditions, Queen Charlotte City, B.C.), N. Gessler (University of California, Los Angeles, California), personal communications; 9. Stacey et al. 1989. 10. Royal British Columbia Museum.
[c]For the purposes of determining the total number of separate occurrences in Canadian water records from the same date and in close proximity are considered a single occurrence and the five records from August and September 1978 are likely repeat sightings of the same individuals in the same general area.
[d]Specimen collected and held at the Vancouver Public Aquarium.
[e]Specimen collected and held at the Queen Charlotte Islands Museum, Skidegate.
[f]Specimen collected and held at the Royal British Columbia Museum (BCPM 16670).
[g]Specimen collected and held at the Royal British Columbia Museum (BCPM 16904).

although the distribution relative to depth was broadly defined (CETAP 1982).

Risso's Dolphins have been recorded in waters with surface temperatures ranging from 4.5° to 28°C, although in the area from Cape Hatteras to the Gulf of Maine 90% of all sightings were in waters that fell within the range 21.3° to 25.1°C (CETAP 1982). In the Pacific, sightings have been reported in water temperatures between 10° and 28°C (Leatherwood et al. 1980). A recent record in British Columbia is from mid-winter (January), when water temperature was approximately 8.2°C (Baird et al. 1988).

General Biology

Reproduction

The length at birth ranges from 110 to 166 cm (Tomilin 1957; Mizue and Yoshida 1962). Risso's Dolphins become sexually mature at about 3 m in length and are believed to live at least 20 years (Leatherwood et al. 1982). Age at first reproduction and calving interval are not known (Mitchell 1975a). There are several reports on the possible timing of births. Tomilin (1957) suggests that births may occur in winter. In one study in Monterey Bay, California, the smallest calves were observed in November (Kruse 1987). In CETAP surveys along the northeast coast of the United States, the seasonal number of calf sightings related to the total number of sightings was relatively similar. It seems from this information that calves may be born in all seasons, and perhaps geographical differences exist; however, further investigation is needed. Information gathered from 23 females driven ashore in Japan suggests that gestation time may be 13 to 14 months; gross reproductive rate in this group was 6 to 7% (Kasuya 1985). Hybridization with Bottlenose Dolphins both in the wild and captivity has been reported (Fraser 1940; Leatherwood and Reeves 1983).

Species Movement

Based on stranding data from the United Kingdom spanning 53 years, Sergeant (1982)

suggests that some populations of odontocetes may change in abundance with time. However, these records indicate that Risso's Dolphin numbers were consistent there throughout that period. There may be long-term fluctuations in the geographical ranges of Risso's Dolphins, possibly in response to long-term environmental changes (Leatherwood et al. 1980). Leatherwood et al. (1980) note that records of Risso's Dolphins in the North Pacific from latitude 45° to 51°N are most abundant during summer, and appear to relate to the warming of surface waters. However, records from British Columbian waters presented here (Table 1) do not appear to corroborate this seasonal trend, especially considering the lack of search effort during winter months. In the northeastern Pacific, until 1971, Risso's Dolphins were usually sighted in waters deeper than 100 fathoms. Since then, and increasing in frequency to 1975, most sightings were over the continental shelf where, in 1974 and 1975, sea surface temperatures were unusually high (Leatherwood et al. 1980). Events such as the El Niño in the North Pacific in the 1980s can be accompanied by range extensions (Leatherwood et al. 1987).

In the North Atlantic, seasonal migrations to higher latitudes have been suggested (Mitchell 1975a). In the northwestern Atlantic between Cape Hatteras and the Gulf of Maine, a general northward expansion of range reaches its maximum in summer, as does the number of individuals (CETAP 1982). A marked contraction in the occupied habitat and an emigration from the study area, to offshore or southern waters or both, were also found. Kasuya (1971) reports that, in winter, Risso's Dolphins migrate to the coastal waters adjacent to the north and west coast of Kyushu, Japan. In U.S. National Marine Fisheries Service surveys in the eastern tropical Pacific, no temporal trend in relative abundance of cetacean schools was evident over the four-year study period (Polacheck 1987). No seasonal variation in group size of Risso's Dolphins has been found in a study of Monterey Bay, California (Kruse 1987).

Behaviour

Mean reported group sizes range from approximately 11 (Leatherwood et al. 1980) to 45 (Kruse 1987) in the eastern North Pacific. The analysis of Leatherwood et al. showed a modal group size of two, and a range of 1 to approximately 220 individuals, with no differences in group sizes between different areas or seasons (Leatherwood et al. 1980). The Cetacean and Turtle Assessment Program (CETAP 1982) recorded a mean group size of 17.2 in the northwest Atlantic between Cape Hatteras and the Gulf of Maine, with a range of 1 to 400. The mean group size from Canadian sightings presented in Table 1 is approximately 9, with a range from 2 to 30 individuals (n = 14). Maximum reported group size appears to be a group of over 2000 individuals seen off Washington State (Braham 1983).

Based on a photo-identification study, Kruse (1987) suggests that Risso's Dolphins may have a fairly cohesive social organization in which individuals stay together for extended periods of time. However, the age and sex composition of groups is not known (Leatherwood et al. 1982). In the eastern tropical Pacific they are most often found as a small component of schools of other types of dolphins (Polacheck 1987). The number of large groups sighted and their frequent association with other small cetaceans such as Northern Right-Whale Dolphins (*Lissodelphis borealis*), Short-finned Pilot Whales, Pacific White-sided Dolphins (*Lagenorhynchus obliquidens*) (Fiscus and Niggol 1965), Dall's Porpoise (*Phocoenoides dalli*) (Braham 1983), and Dusky Dolphins (*Lagenorhynchus obscurus*) (Wursig and Wursig 1980) suggest a gregarious nature. However, in the northwest Atlantic, Risso's Dolphins were only rarely observed in association with other species (CETAP 1982). Shane (1987) has observed apparently aggressive interactions between Risso's Dolphins and Short-finned Pilot Whales.

One factor relating to sighting frequencies is the relative visibility of Risso's Dolphins compared to other species. Only anecdotal observations are available on their reactions to vessels, and many are conflicting. Tomilin (1957) reports that Risso's Dolphins often follow moving vessels, while others suggest that they are usually shy of small vessels but will ride the bow wave on larger ships (Department of Commerce 1984). Schevill (1954) reports that Risso's Dolphins stayed 75 yards from his ship but would come up to a dory when it was launched. Pilleri and Gihr (1969) and Pike and MacAskie (1969) also describe bow-riding. Risso's Dolphins breach clear out of the water, slap their sides or tails on the surface (Leatherwood et al. 1982) and are known to surface with only their tail or head showing above the water (Pilleri and Knuckey 1969). These behaviours suggest that the lack of sightings in some areas where surveys have been undertaken may correspond more with an absence of Risso's Dolphins, rather than a possible avoidance of vessels or a difficulty in spotting them.

Limiting Factors

Historically, Risso's Dolphins have not supported a major fishery. Small numbers have been taken in small whale fisheries in European waters (Duguy and Hussenot 1982), off Sri Lanka (Alling 1985; International Whaling Commission 1986), the Lesser Antilles (Caldwell et al. 1971), Peru (Read et al. 1985), along the east coast of the

United States, Japan, Indonesia, the Indo-Australian archipelago, the Solomon Islands and in the East China Sea (Mitchell 1975b; International Whaling Commission 1984; Reeves and Leatherwood 1984) and they are caught incidentally in fishing nets (Mitchell 1975b; International Whaling Commission 1983). In the Iki Island area of Japan, they have been deliberately killed to reduce competition with fisheries (Kasuya 1985).

Killer Whales (*Orcinus orca*) and large sharks, well known marine predators, could prey on Risso's Dolphins. Potentially, False Killer Whales (*Pseudorca crassidens*) might also prey on Risso's Dolphins, as they have been seen preying on small delphinids (*Stenella* spp. and Common Dolphins) (Perryman and Foster 1980), and a Humpback Whale calf (*Megaptera novaeangliae*) (Hoyt 1983). However, it appears no incidents of predation have been reported (Jefferson et al. 1991), and it is unlikely that predation has much effect on populations.

Continuous introduction of toxic chemicals into the dolphins' habitat occurs, but the absolute effect of these chemicals on cetaceans is still unclear. Martineau et al. (1987) present evidence that Beluga Whales (*Delphinapterus leucas*) from the St. Lawrence Estuary are contaminated by compounds known to induce severe reproductive dysfunctions in many other animal species at similar concentrations. They suggest that organochlorine contamination should be considered as a prime cause for the low recruitment observed in this population. Risso's Dolphins are not typically an inshore coastal species and would thus presumably have less exposure to high levels of chlorinated hydrocarbons (Gaskin 1985). However, high levels of both organochlorines and heavy metals have been found in the tissues of two False Killer Whales, typically an offshore species, which stranded in British Columbia (Baird et al. 1989; Langelier et al. 1990). The effects of industrial activities, such as oil and gas exploration in the Risso's Dolphins' habitat along the eastern United States continental shelf, as well as shipping and fishing, are largely unknown but warrant further study (Hain et al. 1985). During the monitoring of an oil spill southeast of Cape Cod using aerial surveys, Goodale et al. (1981) observed no attraction or repulsion between cetaceans and oil.

Mass strandings of Risso's Dolphins have been reported and could be detrimental to local populations (Leatherwood et al. 1979). Preliminary observations of cetacean strandings in British Columbia indicate that species at the northern limits of their range are disproportionately represented in strandings compared to their observed abundance. This suggests that cetaceans outside of their usual range and habitat, such as Risso's Dolphins in coastal Canadian waters, may tend to strand more often (Baird et al. 1988).

Special Significance of the Species

Many populations of dolphins and small whales are exploited directly or incidentally and must be assessed and managed (Perrin and Reilly 1984). Risso's Dolphins and other small cetaceans have generally received little attention and concern compared to the larger, commercially-harvested species. Yet one individual, named "Pelorus Jack", may be one of the most well-known individual wild cetaceans. It escorted ships into Admiralty Bay in New Zealand over a period of up to 17 years (Leatherwood et al. 1982). Risso's Dolphins have been kept in a variety of aquariums and oceanariums both in Japan and the United States (Leatherwood et al. 1982). Their presence in these facilities has brought increasing attention and interest to them and other small cetaceans. Captive specimens in Japan have survived for over five years and have successfully conceived and given birth. However, increasingly complex factors may be affecting their populations and status. Implications of toxic chemicals on mortality in populations are not yet known.

Evaluation

Occasional catches incidental to small-whale fisheries will probably continue as long as these are in operation (Mitchell 1975a). There is no evidence that this species is common in Canadian waters, although it does not appear to be under any particular risk here. Based on the small number of data available, it is impossible to determine population trends.

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Addendum

Three additional records of this species from Canadian waters in July and August 1990, after the completion of this paper, are included here. H. Whitehead, Dalhousie University, reports a record obtained from F. D'Entremont of 16 individuals sighted 30-31 August 1990 at 42°15′N, 66°40′W, in Canadian waters south of Nova Scotia. R. Waryk and A. Preston of the FPV Tanu observed a group of approximately 10 individuals, including four calves or small juveniles, on 7 July 1990 at 50°03′N, 127°56′W, off the northwest coast of Vancouver Island. The depth of water for this sighting was 65 fathoms, and the sea surface temperature was 14.8°C. In the same area on 25 August 1990, D. Nelson and P. Murphy of the same vessel photographed a group of about 30 individuals, including at least six calves or small juveniles, at 50°15′N, 128°05′W. The depth of water for this sighting was 75 fathoms, and the sea surface temperature was 15.2°C.

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Status of the Northern Right Whale Dolphin, *Lissodelphis borealis*, in Canada*

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Baird, Robin W., and Pam J. Stacey. 1991. Status of the Northern Right Whale Dolphin, *Lissodelphis borealis*, in Canada. Canadian Field-Naturalist 105(2): 243–250.

The Northern Right Whale Dolphin, *Lissodelphis borealis*, is one of the most abundant oceanic dolphins in its range in the North Pacific, but little is known about its biology or distribution. The biology and management of this species are summarized with special reference to its status in Canadian waters. Seventeen occurences of the Northern Right Whale Dolphin from within the Canadian 320 km (200 mi) extended economic zone are presented; only one occurrence has been previously published. Seven of these records are of animals killed in a Canadian experimental Flying Squid (*Ommastrephes bartrami*) driftnet fishery in 1986 and 1987, which has since been discontinued. Lack of comprehensive recording of sightings, strandings and incidental catches render the exact status of this species in Canadian waters unclear. Based on the best available information, the Northern Right Whale Dolphin is rare in Canadian waters, where it is in the outermost limits of its normal distribution.

Le dauphin à dos lisse, *Lissodelphis borealis*, est l'un des dauphins océaniques les plus commans dans le Pacifique Nord, mais on connaît très mal sa biologie et sa répartition géographique. Ce rapport résume la situation, la biologie et la gestion de l'espèce, en insistant particulièrement sur son statut dans les eaux canadiennes. Il présente une observation publiée et dix-sept observations inédites, provenant de la zone exclusivement économique du Canada (ZEE) qui s'étend jusqu'à 320 km (200 milles) des côtes. Sept d'entre elles concernent des animaux tués au cours de pêches expérimentales de l'Encornet volant (*Ommastrephes bartrami*) aux filets dérivants en 1986 et 1987, auxquelles ont a mis fin depuis. Bien que la situation du Dauphin à dos lisse dans les eaux canadiennes soit encore mal connue vu l'absence de rapports complets sur les observations, les échouages et les prises accidentelles, les meilleures données accessibles indiquent que cette espèce est rare dans ces eaux situées à l'extrême limite de son aire de répartition.

Key Words: Northern Right Whale Dolphin, Dauphin à dos lisse, *Lissodelphis borealis*, Canada, cetacean status, North Pacific.

This report reviews the status, biology and management of the Northern Right Whale Dolphin, *Lissodelphis borealis* (Peale 1848), with particular reference to its status in Canada.

The Northern Right Whale Dolphin is a small dolphin, distinguished primarily by its elongate streamlined body and lack of a dorsal fin. It is the only finless delphinid in the North Pacific (Figure 1). The flippers and flukes are narrow and pointed. Maximum length is at least 3.1 m in males, and 2.3 m in females. The coloration is largely black, with a clearly demarked white ventral marking extending forward as a narrow band from the caudal peduncle, expanding into a wide thoracic patch. In females this white band is wider in the genital area than in males. A small white patch usually is present slightly posterior to the tip of the lower jaw (Figure 2). The dorsal surface of the flukes is mostly light grey, while the ventral surface is largely white except at the tail stock. Calves are much lighter dorsally than adults, ranging in colour from cream to a light grey (Leatherwood and Walker 1979). Variations in the location and extent of white markings have been noted off California and Japan (Nishiwaki 1972; Leatherwood and Walker 1979). Nishiwaki (1972) classified these two colour forms as subspecies (*L. b. borealis* and *L. b. albiventris*) with *L. b. borealis* having the typical coloration and *L. b. albiventris* having expanded white ventral markings. However, these subspecies designations have not been generally accepted (Leatherwood and Walker 1979). Individuals with the anomalous coloration are not uncommon among herds of normally coloured individuals (Leatherwood et al. 1982).

Distribution

The Northern Right Whale Dolphin is endemic to the North Pacific Ocean. It ranges from Alaska to Baja California in the eastern Pacific, and from Japan to the Aleutians in the western Pacific (Leatherwood and Walker 1979; Kajimura and

*Report accepted by COSEWIC 11 April 1990 — no status designation required.

FIGURE 1. A Northern Right Whale Dolphin riding a vessel's bow wave off California, showing elongate streamlined body lacking a dorsal fin. Photo by Steve Cooper.

FIGURE 2. Northern Right Whale Dolphins riding a vessel's bow wave off California, showing white coloration on ventral surface. Photo by Tom Jefferson.

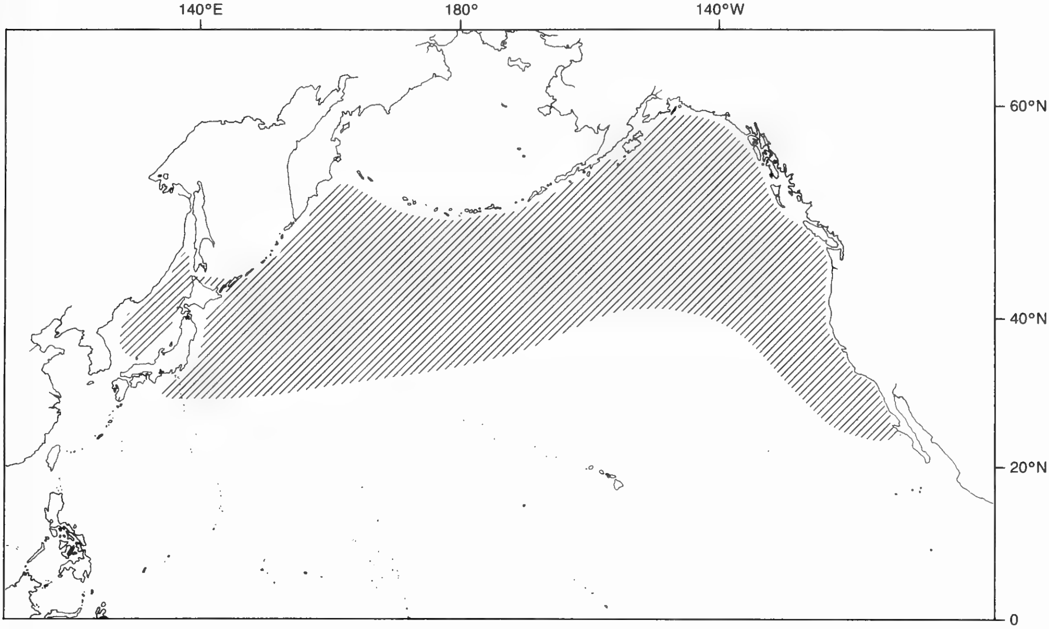

FIGURE 3. Approximate range of the Northern Right Whale Dolphin. There are only a few published records from the western Pacific and effort in pelagic waters is limited, so actual range may differ from that shown.

Loughlin 1988; Figure 3). A few sightings have been reported from the Gulf of Alaska north of 55° N, and there is one record from the central Aleutian Islands (Kajimura and Loughlin 1988). Pike and MacAskie (1969) and Leatherwood and Walker (1979) each presented a record from international waters offshore of British Columbia.

Within the Canadian 320 km (200 mile) extended economic zone (EEZ) the only previously published occurrence is of a single animal collected from a school of about 200 individuals sighted in 1970 (Guiguet and Schick 1970). We have treated this occurrence as two separate records in Table 1 to distinguish between sighting and the collection. A total of 17 unpublished records were compiled from a variety of sources and are also presented in Table 1. In one other case an occurrence was again classified as two records (incidental catch - died, incidental catch — released alive) giving 19 records and 17 separate occurrences of the Northern Right Whale Dolphin in Canadian waters (Figure 4). In their sighting map for this species, Kajimura and Loughlin (1988) show a summer record off Vancouver Island prior to 1982 obtained through the U.S. National Marine Mammal Laboratory (NMML) Platforms of Opportunity Program, but present no details. Based on the source of the record, the season, locality, and date, this record most likely corresponds to our record of 15 September 1978 (*see* Table 1). All of the British Columbia records are from the southern half of the waters under consideration. One sighting record is from shallow water off the west coast of Vancouver Island, but no other documented inshore sighting records exist from either British Columbia or Washington. There is one unverified report of a group of five individuals in Puget Sound, Washington in 1977 (Osborne et al. 1988) and there are several stranding records on the outer Washington coast (Scheffer and Slipp 1948). No strandings had been recorded in British Columbia up to 1989. Eight of the records were collected during a Canadian experimental driftnet fishery for Flying Squid, *Ommastrephes bartrami*, (Jamieson and Heritage 1987, 1988).

The large number of records in recent years either indicates an unusual extension into northern waters, or reflects the circumstances of the experimental squid fishery and other increases in sighting effort, allowing for better recording of actual numbers in offshore Canadian waters. Until recently, there have been only a few cetacean sighting records compiled from offshore waters in British Columbia by Canadian authorities or researchers. A lack of experienced observers also contributes to the scant knowledge of distribution and abundance. Reporting of records of species like the Northern Right Whale Dolphin, which are not actively being studied, is very poor in British Columbia. As well, because records are not

TABLE 1. Records of the Northern Right Whale Dolphin within the Canadian 320km (200 mi) extended economic zone.

Date	Location	Number	Type[a]	Source[b]
13 February 1970	48°23′N, 126°52′W	200 ±	1[c]	1
13 February 1970	48°23′N, 126°52′W	1	2[c,d]	1
15 September 1978	49°49′N, 128°22′W	5 ± 1	1	2
21 July 1982	48°36′N, 126°45′W	unknown	1	3
20 July 1983	50°45′N, 132°30′W	3	1	2
28 March 1984	49°01′N, 125°41′W	2	1	2
21 November 1984	48°N, 127°W	unknown	1	3
24 July 1986	48°29′N, 129°32′W	1	3	4
25 July 1986	48°24′N, 129°39′W	1	3	4
14 August 1986	50°37′N, 131°12′W	1	3	4
14 August 1986	50°25′N, 132°20′W	1	3	4
17 September 1986	48°01′N, 128°42′W	6	1	3
15 October 1986	48°36′N, 126°21′W	4	1	3
12 July 1987	47°31′N, 130°01′W	1	3	4
27 July 1987	48°30′N, 120°31′W	1	3	4
28 July 1987	48°36′N, 129°35′W	1	3[c]	4
28 July 1987	48°36′N, 129°35′W	1	4[c]	3
24 September 1987	48°40′N, 127°04′W	10	1	3
30 August 1988	48°05′N, 120°10′W	5	1	5

[a]Type of Record: (1) Sighting; (2) Collection; (3) Incidental catch, died; (4) Incidental catch, released alive.
[b]Source of Data: (1) Guiguet and Schick 1970; (2) NMML Platforms of Opportunity Program, Seattle, Washington; (3) Crew of the CSS Parizeau, courtesy M. A. Bigg, Pacific Biological Station, Nanaimo, British Columbia; (4) G. D. Heritage, personal communication, Pacific Biological Station; (5) K. Morgan, personal communication, Canadian Wildlife Service, Sidney, British Columbia.
[c]For the purposes of discriminating between type of record (ie., Sighting; collection; incidental catch, died; incidental catch, released alive); there are two records for this occurrence, but in determining the number of occurrences of this species in British Columbia waters, these are combined and considered only once.
[d]This appears to be the only specimen record from British Columbia, held at the Royal British Columbia Museum, Victoria (BCPM 6982).

compiled in one central facility, it is likely that other unpublished records exist but were not available to us. However, based on the available information, the scarcity of records in Canadian waters and the increasing frequency of records progressively southward suggest that Northern Right Whale Dolphins are in the outermost limits of their normal distribution in Canadian waters.

Protection

International

Regulation of international trade between members of the Convention on International Trade in Endangered Species of Wild Fauna and Flora 1973 (CITES), and between non-members and Convention members, has been established by listing the Northern Right Whale Dolphin under Appendix II of the Convention (see Birnie 1982). The International Whaling Commission (IWC) regulates the taking of whales in accordance with the current Schedule provisions, but this regulation may not apply to the Northern Right Whale Dolphin as members of this Convention are divided as to whether "whale" refers to all cetaceans, or only to some species (Klinowska 1987).

National

Canada: The 1982 Cetacean Protection Regulations of the Fisheries Act of Canada 1867 (as amended to date) prohibit hunting of this and other species (except by aboriginal peoples who are allowed to take whales for subsistence purposes). "Hunting" is defined as to "chase, shoot at, harpoon, take, kill, attempt to take or kill, or to harass cetaceans in any manner", and may only be undertaken under permit from the Minister of the Department of Fisheries and Oceans.

United States: All cetaceans are protected under the Marine Mammal Protection Act of 1972, as well as through the Packwood-Magnuson Amendment of the Fisheries and Conservation Act and the Pelly Amendment of the Fisherman's Protective Act.

Population Size and Trends

Nishiwaki (1972) suggested that the world population for this species was over 10 000

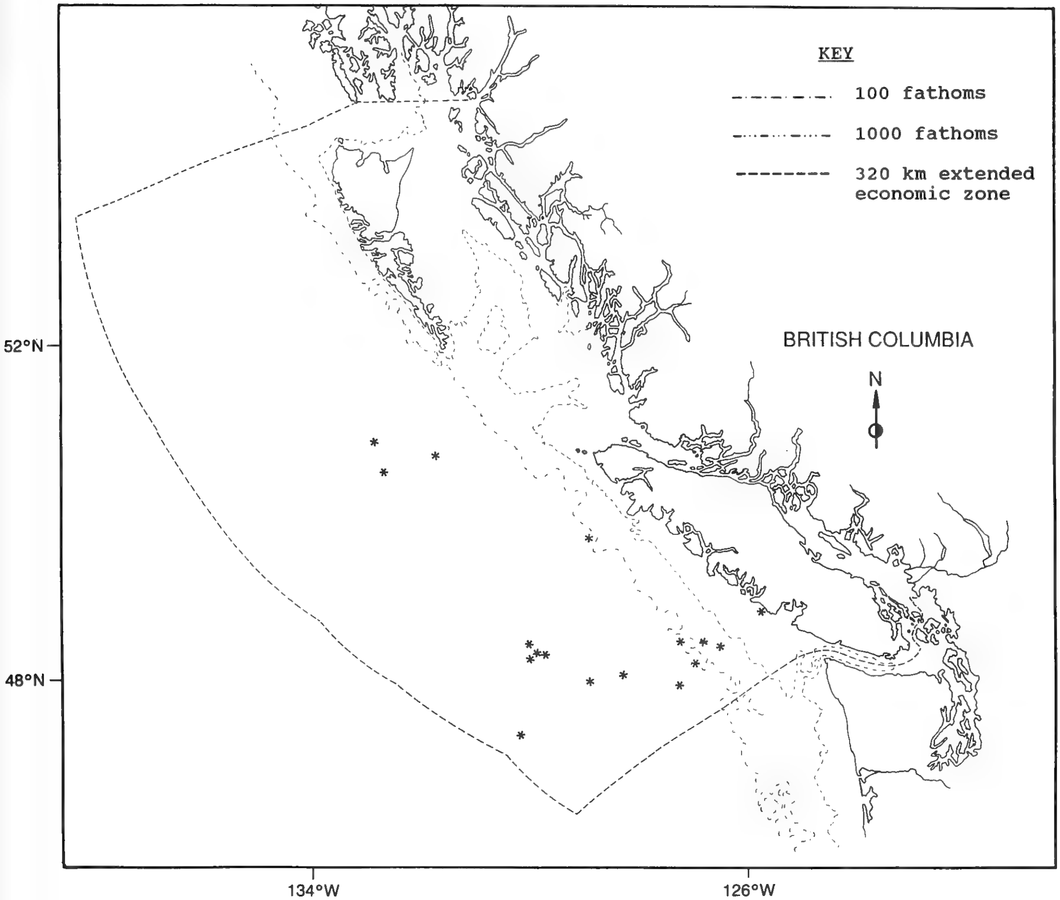

FIGURE 4. Records of the Northern Right Whale Dolphin in the Canadian 320 km (200 mi) extended economic zone.

individuals, but Leatherwood and Walker (1979) gave a tentative estimate of 17 800 individuals for a 20 000 square mile area off southern California. No recent estimate of total population size exists, but Northern Right Whale Dolphins appear to be among the most abundant of the oceanic dolphins that inhabit the temperate North Pacific (Leatherwood and Reeves 1983). Present population trends are unknown due to scarcity of reported sightings and lack of distributional surveys.

Leatherwood and Walker (1979) analyzed all known records from the eastern Pacific. Prior to their work, there had only been 33 published records from the eastern Pacific since the species was originally described in 1848. Of the 184 records where herd sizes were noted, the number of individuals ranged from one to 2000 with a mean group size of 110 individuals (Leatherwood and Walker 1979). Large herds of up to 3000 individuals have been reported, and herds of 1000 animals or more are often seen (Leatherwood et al. 1987). Of the eight sightings in British Columbia waters for which group size information is available (Table 1) the mean was approximately 29 individuals, with a range from two to 200. However seven of the eight records are of 10 or fewer individuals; excluding the single record of 200 gives a mean of five individuals. Leatherwood and Walker (1979) noted that there were no significant differences between herd sizes north and south of Point Conception, California, or between those over and off the continental shelf.

Habitat

In the eastern North Pacific, Northern Right Whale Dolphins have been recorded from waters ranging in temperature from 7.8 to 18.9°C (Leatherwood and Walker 1979). Water temperatures were available from nine British Columbia records and ranged from 13.5 to 16°C (temperatures from Jamieson and Heritage 1987, 1988;

NMML Platforms of Opportunity Program; K. Morgan, personal communication). This range is biased as all records were from either July or August.

Northern Right Whale Dolphins appear to favour deeper water habitats but will approach shore at the heads of deep canyons, particularly in winter (Leatherwood and Reeves 1983). Sixteen of 17 occurrences from British Columbia are from water depths of 500 fathoms or greater, with the remaining record, from March 1984, in shallow water off the west coast of Vancouver Island. The offshore habitat of the Northern Right Whale Dolphin is generally less susceptible to human impact and degradation than are coastal areas.

General Biology

Reproduction

Very little is known about the reproductive biology of this species because few specimens have been available for study from fisheries or strandings and because they have not generally survived well in captivity (Reeves and Leatherwood 1984). It appears that males are mature sexually at lengths of about 2.2 m, and females are mature at about 2.0 m (Leatherwood and Walker 1979; Bryden and Harrison 1986). Estimates of the length at birth have ranged from 60 to 100 cm. Calves are reportedly born in the early spring (Leatherwood et al. 1982). No estimates of gestation period, calving interval, or longevity have been reported. Only one of five individuals that have been taken into captivity in the United States survived for more than three weeks (Reeves and Leatherwood 1984). This individual lived for 15 months (Walker 1975).

Species Movement

Northern Right Whale Dolphins tend to move southward and inshore in late fall and northward and offshore in spring (Leatherwood et al. 1982). Based on sightings in the southern California continental borderland area, they are only seasonal visitors from October through May, with a peak in sightings in January (Leatherwood and Walker 1979). Their appearance in this area generally coincides with peaks in abundance of Market Squid (*Loligo opalescens*), a major prey item (Leatherwood and Walker 1979). Northern Right Whale Dolphins appear to move south of 30° N only during periods of intrusion of unseasonably cold waters (Leatherwood et al. 1987). No seasonal trends are apparent in British Columbia; records have been obtained from seven months of the year in all seasons (Table 1). A peak in sightings during July is probably due to an increase in effort.

Behaviour

Northern Right Whale Dolphins feed on a variety of cephalopods and fish (Leatherwood and Walker 1979; Clark 1986). Distinct patterns of herd configuration are described by Leatherwood and Walker (1979). Northern Right Whale Dolphins have been frequently reported in association with other species of marine mammals, including the Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*), Risso's Dolphin (*Grampus griseus*), Dall's Porpoise (*Phocoenoides dalli*), Short-finned Pilot Whale (*Globicephala macrorhynchus*), Common Dolphin (*Delphinus delphis*), Bottlenose Dolphin (*Tursiops truncatus*), Baird's Beaked Whale (*Berardius bairdi*), Gray Whale (*Eschrichtius robustus*), Humpback Whale (*Megaptera novaeangliae*), Sei Whale (*Balaenoptera borealis*), Fin Whale (*Balaenoptera physalus*), and California Sea Lion (*Zalophus californianus*) [Norris and Prescott 1961; Brownell 1964; Fiscus and Niggol 1965; Leatherwood 1974; Wahl 1977; Leatherwood and Walker 1979; Braham 1983; Kruse 1987; Kajimura and Loughlin 1988]. Intermingling of species however, is relatively uncommon, apparently occurring only with Pacific White-sided Dolphins (Leatherwood and Walker 1979) and Risso's Dolphins (T.A. Jefferson, Department of Marine Biology, Texas A & M University, Galveston, Texas, personal communication). Interspecific associations were noted in four of the records from British Columbia waters, three with Pacific White-sided Dolphins, and one with both Pacific White-sided Dolphins and Short-finned Pilot Whales.

Northern Right Whale Dolphins are often wary of boats and avoid them, either by "sneaking away" with little surface disturbance, or "running" away quickly (Leatherwood and Walker 1979). Speeds of at least 33 km/h (18 knots) can be maintained for protracted periods (Leatherwood et al. 1987). They appear less shy and will more frequently approach vessels and ride their bow waves when in the company of Pacific White-sided and other dolphins (Leatherwood and Walker 1979; Leatherwood et al. 1987).

Limiting Factors

Seven Northern Right Whale Dolphins were incidentally killed in Canadian waters, and an additional six animals killed in international waters in an experimental driftnet fishery for Flying Squid in 1986 and in 1987. This fishery has since been discontinued (Jamieson and Heritage 1987, 1988). They were taken sporadically by whalers in the 19th century (Mitchell 1975). Wilke et al. (1953) note a single whaling company in Japan taking 465 of these dolphins in a two month period in 1949. More recently, and up until 1985, small numbers (less than 40) were taken yearly off Japan incidental to local fisheries (IWC 1983, 1984, 1985, 1986, 1987). The number taken each

year since then has increased with 154 taken in 1986, more than 261 in 1987, and 268 in 1988 (IWC 1988, 1989, 1990). A few have been live-captured off California for aquariums (Walker 1975; Reeves and Leatherwood 1984).

Brain lesions resulting from parasitic infestations by the tremode *Nasitrema* sp. have been found in stranded individuals, and may be a significant cause of single strandings (Dailey 1985). Other parasites have been recorded from Northern Right Whale Dolphins, including the nematodes *Crassicauda* sp. and *Anisakis* sp., and the cestode *Phyllobothrium* sp. (Dailey and Brownell 1972; Dailey 1985; Cowan et al. 1986), but little is known of the influence of these parasites on the natural mortality of the species.

Natural predators are not known, but may include the Killer Whale (*Orcinus orca*) and large sharks. Strandings are uncommon, only 35 having been recorded between 1848, when the species was described, and 1978 (Leatherwood and Walker 1979; Leatherwood et al. 1987). However in 1981, 23 strandings were recorded from south central and southern California beaches (Woodhouse et al. 1985). Mass strandings have apparently not been reported in this species, although there are two records of mass strandings in the closely related Southern Right Whale Dolphin (*Lissodelphis peroni*) in New Zealand (Fraser 1955; Cawthorn 1990). No information appears to be available on environmental contaminant levels in this species.

Special Significance of the Species

Although normally wary of boats Northern Right Whale Dolphins appear less shy, and will more frequently approach vessels and bow ride when in the company of Pacific White-sided and other dolphins (Leatherwood and Walker 1979; Leatherwood et al. 1987). This species has been successfully maintained in captivity for at least 15 months (Walker 1975), but most captured individuals have lived for much shorter periods (Reeves and Leatherwood 1984). They are not a comercially important species and except for the small whale fishery of Japan are not taken for food. Due to their offshore habitat they are rarely observed and are less susceptible to the impact of human activities.

Evaluation

Small catches incidental to Japanese coastal fisheries can be expected (Mitchell 1975). There is no evidence that this species is, or ever was, hunted in Canadian waters. Based on the small amount of data available it is impossible to determine population trends, and, in fact, based on the known lack of effort for censusing cetaceans in British Columbia, it is probable that this species occurs much more frequently than documented here. As long as incidental catches in offshore Canadian fisheries are prevented or severely limited, its status in Canadian waters should not change. Evaluated in light of the best available information, it appears that the Northern Right Whale Dolphin is rare in Canadian waters, as it is at the outermost limits of its normal distribution, but it is not particularly at risk here.

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Observations on Soil Requirements for Nesting Bank Swallows, *Riparia riparia*

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John, Roy D. 1991. Observations on soil requirements for nesting Bank Swallows, *Riparia riparia*. Canadian Field-Naturalist 105(2): 251–254.

A penetrability test, devised to examine the soil conditions, was used to investigate Bank Swallow nesting sites. The choice of location for the colony examined seems, at least in part, determined by the degree of soil compactness.

Key Words: Bank Swallow, *Riparia riparia*, soil characteristics, nesting criteria.

There has been growing concern over declines in many bird species in America, Europe, and elsewhere. Gammell (1987) reported that the numbers of European Bank Swallows (*Riparia riparia*) have declined to 7% of the levels of 20 years ago. There is some speculation that deteriorating conditions in the wintering areas are the primary cause. Kelly (1985) attributed European loss to the droughts in Central Africa, a critical staging area for trans-Saharan migrants. North American data are not suited to monitoring colonial species and are too imprecise to make accurate assessments. However, workers in the Ontario Breeding Bird Atlas (Cadman et al. 1987) and some Ontario banders believe that the Bank Swallow has declined here also.

The Bank Swallow is one of two obligate bank-nesting North American Swallows. The other is the Northern Rough-winged Swallow (*Stelgidopteryx serripennis*). The Bank Swallow is somewhat better adapted for digging than the latter (Gaunt 1965). There are some ambiguous statements in the literature implying that the rough-wing also digs its own nest burrows, but hard evidence is lacking. It may enlarge or clean out an existing hole but likely only digs a new burrow under exceptional circumstances (Link 1962).

Bent (1942) gave a description of the construction and general characteristics of typical Bank Swallow nests. Sharrock (1976) stated the birds had a preference for sand over clay or chalk. Neither, however, indicated how the birds select the precise locations for the nest site. Gaunt (1965) evaluated the birds' ability to dig, but did not consider the nature of the nesting substrate in influencing the choice of site, suggesting only that some banks were abandoned because of the "texture of the substrate". Erskine (1979) examined the Canadian nest records up to 1974 for swallows and estimated the potential of human influence but did not attempt to show any relationship between the bank characteristics and its suitability as a site. Peterson (1955) described burrow excavation and noted that, in locations which had extensive vertical banks that appeared suitable, the colonies were tightly grouped. He stated the distance between burrows is determined by the area swallows can defend. The higher locations are easier to defend and the burrows there are excavated more quickly, thus concentrating colonies in narrow bands at the top of the bank. He did not consider the effect of the soil conditions, but did observe that burrows were deeper when excavated in sand (92% sand) compared to sandy-loam (65% sand).

While participating in the Ontario Breeding Bird Atlas project, I noted that only some apparently suitable nesting sites were used, that birds were confined to relatively few areas and that, within a colony, the nest holes tended to be close together. Adjacent, similar-appearing areas were either abandoned or unused. This raised questions as to which variables were important ato the selection of sites for nesting colonies by Bank Swallows. This paper presents my investigations of some of the physical characteristics of a typical nesting site.

Study site

The area chosen was a large, disused sand and gravel excavation to the west of Ottawa, located at the junction of highways 417 and 5 (45° 17′N, 75° 58′W). The site had not been worked for some time and was largely overgrown. It was a complex of pits with cliff faces bordering on standing water or bare pit bottoms. The area was private, fenced and guarded, and therefore suffered little disturbance. Although the western end of the pit was used as a garbage dump, this use was sufficiently remote that did not appear to affect the nesting activities.

Methods

A device to measure the penetrability of the soil was constructed from a telephone message or office desk spike (see Figure 1). It consisted of a

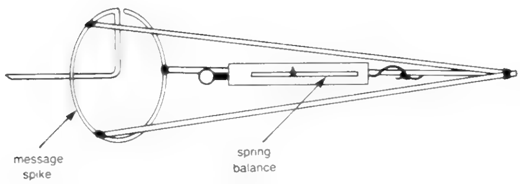

FIGURE 1. Measuring device for determining the penetrability of soil (not to scale: see text for details).

7.5 cm diameter base with 1 cm feet and a 10 cm spike. This was fitted to three 0.6 m wooden rods with telephone wire. The rods were joined in the shape of a tepee above the inverted message spike. A loop fixed to the apex of the rods allowed a spring balance to be attached. When the point of the spike was placed on the soil surface, either vertically or horizontally, and the balance pulled, the balance reading gave a measure of the force required to sink the spike its full length. On all occasions, the spike remained motionless as the force was increased to the point where penetration occurred. Then the spike sank rapidly to or near to its full length. Many trial repetitions within a narrow area gave repeatable readings. I assumed that the measurement was adequately reproducible, at least in the hands of a single operator, to give a gross indication of the differences in soil compaction. I used this equipment to measure penetrability of the soil in areas adjacent to the nest site. Although not an absolute measurement, it reflects the compactness and hence the stability of the soil. Samples of soil for particle size composition were collected at three appropriate sites by digging holes 10 cm deep. Using this technique a total of 53 readings were taken at 6 different locations.

Results and Discussion

The penetration tests were first done on the surface of the cliff top immediately above an active nest colony (Figure 2). The force required to sink the spike was 2.65 kg (Table 1). The soil from this area was dark brown sand and had the highest proportion of medium and coarse sand (31%) with an organic content of 3.5% (Table 2). The latter is not surprising as this was a vegetated surface in the early stages of building up a humus layer in the topsoil. The lower force required for penetrability (compared to that of the nesting cliff) can be explained by the effect of frost action at this upper surface.

The second set of measurements was taken from the face of the nesting cliff, immediately adjacent to active nest holes. Here the average was 8.9 kg. On occasion the force required was greater than 11.8 kg, the limit of the spring scale. Although the measurements near nest sites were more variable than those at the upper surface they were nevertheless consistently higher, indicating a more firm and stable matrix. Unfortunately, it is difficult to rationalize this physical difference from the grain size distribution or the organic content with either the first set of samples or the following set.

Penetrability readings were then taken moving away from the nesting zone. The first three of these, performed 6 m away, were all 2.7 kg, a far lower value than those adjacent to nests which indicated soft and crumbly sand. Farther away (12 m) the values increased slightly and had a greater range, the average being 4.8 kg with a range of 2.7 to 9.1 kg. In this area there was evidence that the cliff had formerly held nests. In another disused nesting slope, seven penetrability measurements gave an average of 2.8 kg. Despite evidence of a large number of previous nests (the cliff had slumped to the point where the terminal nest chambers were exposed) there remained only two active nests. Readings from around one nest hole (approximately 2 cm from the hole itself to avoid damage to the nest hole) gave values of 1.8 to 9.1 kg. The lower values suggest that the slumping process has revealed less firm and stable sand, and this, rather than social forces, was leading to its abandonment as a nest location.

TABLE 1. Penetrability characteristics in the vicinity of Bank Swallow nests.

	Penetrability Kg			
Sample Location	Mean	Std. Dev.	Range	No. of Measurements
On level ground above active nests	2.65	0.24	2.3 to 2.9	10
Active nest area	8.86	2.02	6.8 to 11.8	9
Unused area 6-12 m away with no nesting activity	2.7			3
Evidence of previous nests	4.7	1.47	3.6 to 9.1	17
Newly abandoned site	2.83	1.12	1.8 to 3.6	6
Around nest hole	5.36	3.61	1.8 to 9.1	8

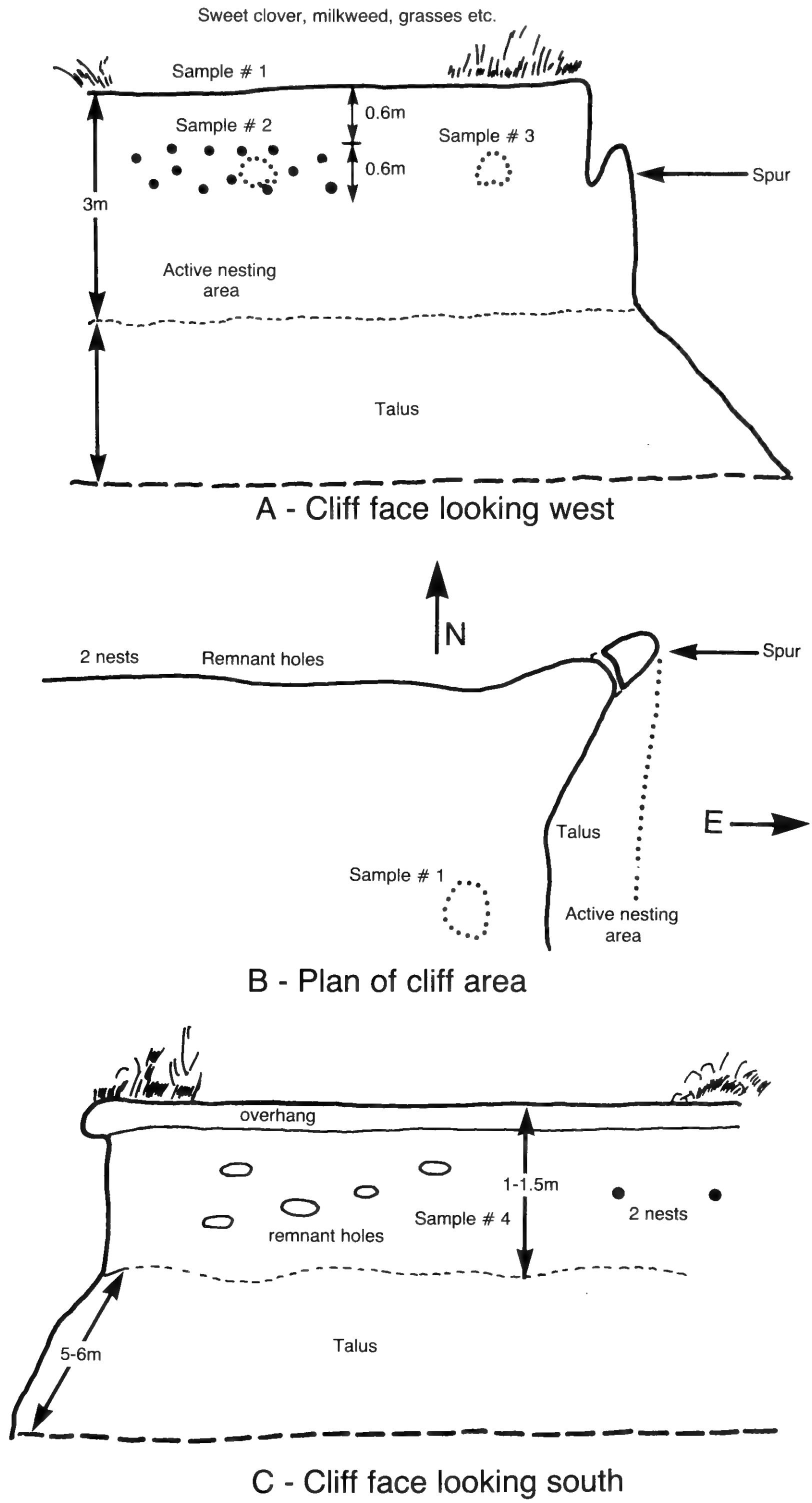

FIGURE 2. Diagrams of aspects of the cliff area where Bank Swallow nests were studied.

TABLE 2. Soil composition in vicinity of Bank Swallow nests.

Sample Location	Grainsize Distribution % wt				Organic Content % wt
	Silt	Sand: Fine	Sand: Medium	Sand: Coarse	
On level ground above active nests	17	48	27	4	3.5
Active nest area	7	61	29	—	0.9
Evidence of previous nests	10	68	19	—	0.7

It was also noted that the birds only nested in cliffs which had sufficient stability to maintain a 3 m vertical face. Unused faces had sufficient talus to leave only a 1 to 1.5 m vertical section. As well as indicating a less stable condition, the high talus piles would allow easier access to terrestrial predators.

It appears, therefore, that Bank Swallows require relatively specific soil conditions to satisfy nesting requirements. These are evidently good quality construction grade sand, with a low organic content and a specific stability as indicated by a penetrability reading of 8-9 kg (as opposed to less than 6 kg). However, it was not possible to further differentiate acceptable from unacceptable soil types from the composition data obtained in this study. Although the social factors postulated by Peterson (1955) are not negated by this study, it is clear that soil characteristics must be acceptable before social considerations can play a role.

These conclusions only define the physical characteristics at this site. Other types of nesting habitat need to be measured to verify the range of applicability of this method. It would be useful to try to reconcile these results with accepted geotechnical techniques.

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Lynx, *Felis lynx*, predation on Red Foxes, *Vulpes vulpes*, Caribou, *Rangifer tarandus*, and Dall Sheep, *Ovis dalli*, in Alaska

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Stephenson, Robert O., Daniel V. Grangaard, and John Burch. 1991. Lynx, *Felis lynx*, predation on Red Foxes, *Vulpes vulpes*, Caribou, *Rangifer tarandus*, and Dall Sheep, *Ovis dalli*, in Alaska. Canadian Field-Naturalist 105(2): 255–262.

Observations of Canada Lynx (*Felis lynx*) predation on Red Foxes (*Vulpes vulpes*) and medium-sized ungulates during winter are reviewed. Characteristics of 13 successful attacks on Red Foxes and 16 cases of predation on Caribou (*Rangifer tarandus*) and Dall Sheep (*Ovis dalli*) suggest that Lynx are capable of killing even adults of these species, with foxes being killed most easily. The occurrence of Lynx predation on these relatively large prey appears to be greatest when Snowshoe Hares (*Lepus americanus*) are scarce.

Key Words: Canada Lynx, *Felis lynx*, Red Fox, *Vulpes vulpes*, Caribou, *Rangifer tarandus*, Dall Sheep, *Ovis dalli*, predation, Alaska.

Although the European Lynx (*Felis lynx lynx*) regularly kills large prey (Haglund 1966; Pullianen 1981), the Canada Lynx (*Felis lynx canadensis*) relies largely on small game, primarily Snowshoe Hares (*Lepus americanus*), for food (Saunders 1963; van Zyll de Jong 1963; Nellis and Keith 1968; Nellis et al. 1972; Brand et al. 1976; Parker et al. 1983). When hares are scarce, the Canada Lynx shows an increased reliance on alternate prey (Brand et al. 1976). Records of Canada Lynx preying on animals other than small game are limited.

There are only two documented accounts of lynx predation on Red Foxes (*Vulpes vulpes*) (Seton 1911), although Dufresne (1946) stated that the remains of foxes consumed by Lynx were commonly found when hares were scarce. Lynx predation on Caribou (*Rangifer tarandus*) neonates has been well documented (Bergerud 1971, 1973), but reports of predation on older, larger Caribou are scarce (Seton 1911; Saunders 1963; Gubser 1965) as are reports of predation on Dall Sheep (*Ovis dalli*) (Sheldon 1930; Bailey 1936). In addition, various authors have alluded to cases of Lynx predation on Caribou or Sheep, but provided no details (Murie 1935; Dixon 1938; Murie 1944). This paper describes additional cases of Lynx predation on Red Foxes, Caribou, and Dall Sheep in Alaska.

The cases of Lynx predation reported here occurred in a variety of forested and semiforested terrain in interior Alaska. This area is covered by taiga, an extension of the boreal forest (Viereck and Schandelmeier 1980). Temperatures frequently reach 25° C in summer and -10 to -40° C in winter. Snow depths are generally below 80 cm, and snow usually remains loosely packed except at high elevations.

Methods

Incidental to field studies during winters 1982-1983, 1984-1985, and 1986-1987 we encountered two instances of successful Lynx predation on foxes, three successful and one unsuccessful cases of attempted predation on Caribou, and one successful attack on a Dall Sheep. These observations led R.O.S. to ask approximately 40 exprienced trappers if they knew of similar occurrences. Ten trappers reported evidence of one or more cases of predation on foxes, and eight reported evidence of predation on Caribou. One trapper reported a case of predation on a Dall Sheep. Informants' reports originated primarily from 1960 to 1985, with one report in the 1930s. Informants names are included in Tables 1 and 2.

In each of these cases, tracks in snow allowed accurate identification of the predator involved and often provided details of the encounter. In addition, Lynx were observed by us or by informants during or after attacks on eight Caribou, two foxes, and one Dall Sheep. The informants contributing information in most cases provided detailed and plausible accounts of their observations and we are confident in their veracity.

We were able to obtain long bones from only two Lynx-killed Caribou and one sheep. The fat level in femur marrow was determined using the dry-weight method (Neiland 1970).

TABLE 1. Cases of Lynx predation on Red Foxes in Interior Alaska, 1930–1983. Both successful and unsuccessful attempts are listed.

Case No.	Date	Location	Sex	Age	Approx. amount consumed	Informant	Informant comments
1	About 1930	Hog Landing, Koyukuk River	Unk	Unk	Unk	J. Huntington	After a Snowshoe Hare population crash, an abundant population of Lynx decimated the local fox population. He found several places where Lynx had killed and eaten foxes, which rapidly became scarce.
2	1970s	North of Galena	Unk	Unk	Unk	S. Cleaver	Found where a Lynx had killed a fox and cached the remains, after which a Wolverine had eaten the rest of the fox.
3	1960s	Northway	Unk	Unk	N/A	D. James	On two occasions Lynx were observed following about 50 m behind a fox. The Lynx appeared to be hunting the fox in each case.
4	1960s and 1970s	Tanana Flats	Unk	Unk	Unk	R. Long	Reports finding, at various times, about 12 foxes that had been killed and eaten by Lynx after short chases. Notes an inverse correlation between Lynx and fox abundance in local areas.
5	1971–1972	Suslota Creek	Unk	Unk	60%	D. Cramer	Found remains of fox recently killed by a Lynx. Tracks showed the fox had emerged from willows 10 m ahead of Lynx traveling on overflow ice. Fox was caught after 20 m chase.
6	March 1976	Ladue River	Unk	Unk	95%	T. Brigner	Found a fox which a Lynx had killed and consumed on the river. Snowshoe Hares and Lynx were abundant at the time.
7	1 November 1982	East of Tanana River near Tower Bluffs	F	Ad	0%	T. Carda	Found carcass of a freshly killed fox on trail. Tracks showed that a Lynx had killed the fox after a struggle. The carcass showed numerous bite wounds on the head and neck and numerous claw marks on the shoulders and back.
8	November 1982	Near Chicken, Taylor Highway	Unk	Unk	50%	D. Carlson	Found a fox recently killed by a Lynx. The trail of the chase was plain in the snow. The front half of fox had been eaten.
9	20 November 1982	Kalutna River, Northway Flats	Unk	Unk	50%	This study (D. Grangaard)	Examination of fresh tracks showed that a large Lynx had encountered a fox while traveling along a lake. The fox ran across the lake but was caught and killed after a 200 m chase. After a brief struggle, the Lynx carried the fox off the lake before consuming it.
10	15 February 1983	Upper Ladue River	Unk	Unk	50%	W. Gramont	Found the half-eaten carcass of a fox that had been killed by a Lynx.

Continued

TABLE 1. *Concluded.*

Case No.	Date	Location	Sex	Age	Approx. amount consumed	Informant	Informant comments
11	6 December 1982	Tok River	Unk	Ad	90%	This study (R. Stephenson)	Adult male radio-collared Lynx was seen feeding on a fox it had killed. An examination of the site showed the fox had been killed on the previous day after a chase lasting more than 30 m. Part of the fox had been cached in the snow and then dug out. Remains included a front and hind leg, tail, pelvis, and skull, which was buried.
12	November 1982	Northway Flats	Unk	Unk	Unk	D. James	No details available. Informant was told that residents of Northway had found a fox killed by a Lynx.
13	February 1983	Nikolai Slough, Koyukuk River	Unk	Unk	99%	K. Dayton	While traveling on the river, the informant came upon a Lynx feeding on a freshly killed fox. Upon returning later in the day, the informant found only 16 cm of the fox's tail remaining.
14	February 1983	Lake south of Galena	Unk	Unk	90%	J. Demoski	Informant found the scattered remains of fox where it had encountered a Lynx at a point on a lake. Lynx caught fox in two bounds.

Results and Discussion

The observations of ourselves and our informants include 13 cases of Lynx predation on Red Foxes and two observations of Lynx stalking foxes. Two of these reports included several cases of predation observed by an individual over a period of time. We also recorded 12 successful and one unsuccessful attacks on Caribou and two successful attacks on Dall Sheep. Pertinent details for attacks on foxes and ungulates are provided in Tables 1 and 2, respectively.

Eight cases of successful predation on foxes, four cases of predation on Caribou, and one case involving a Dall Sheep occurred during winter 1982-1983. The other case of predation on Dall Sheep occurred during winter 1985-1986. During the period 1982 through 1986, Snowshoe Hare populations were low or declining in interior Alaska as evidenced by observations of both trappers and biologists and by a decline in the production and survival of Lynx kittens (Stephenson and Karczmarczyk 1989; Alaska Department of Fish and Game, unpublished data). This suggests that, as noted by previous authors, the incidence of Lynx predation on relatively large animals such as foxes and Caribou increases when Snowshoe Hares are scarce.

Our observations, and those of informants, suggest that Lynx predation on foxes is motivated by hunger. We examined three sites where foxes were killed by Lynx after chases lasting from 20 to 200 meters. In two instances the fox had been almost entirely consumed by the Lynx and in one case parts of the fox had been cached. Informants described 10 additional cases of predation on foxes. Details on the length of all but one chase are lacking, but in each case the Lynx had consumed a large portion of the fox. We were able to examine the intact carcass of only one fox, which showed numerous claw and bite marks on the head, neck, shoulders, and back. Lynx are probably aided in their pursuit by soft snow which places foxes at a disadvantage due to their greater weight load on track. We did not observe or record any instances of Lynx predation on foxes that occurred near sources of food, such as ungulate carcasses or carrion.

Our observations, and those of informants, indicate Lynx usually ambush Caribou at close range but that a protracted encounter may occur before a Caribou is actually killed. During 1982-1983, we examined three sites at which Lynx had killed Caribou after chases ranging from 25 to 400 m. Informants described nine additional cases of predation on Caribou; in one case the chase was observed to cover 135 m. Our observations at the site of the longest chase of 400 m indicated the Lynx initially wounded the Caribou only 46 m

TABLE 2. Lynx predation on Caribou and Dall Sheep, Interior Alaska, 1960–1985.

No.	Date	Location	Species	Sex	Age	Approx. amount consumed	Informant	Informant comments
1	March 1965 or 1966	Nabesna Road	Caribou	Unk	Calf	Unk	D. Fredericks	Came upon a large male Lynx that had just killed a Caribou calf after chasing the Caribou across a road.
2	16 November 1967	Headquarters Area, Denali National Park	Caribou	F	Calf		D. and S. Kogl	Informants saw Lynx feeding on a Caribou killed no more than 12 hours before. Tracks showed the Lynx killed the Caribou after a stalk of about 100 m and an attack covering about 135 m. The Caribou showed numerous wounds around the eyes and ears and along the back.
3	1960s	Headquarters Area, Denali National Park	Caribou	F	Unk	Unk	D and S. Kogl	Informants saw a Lynx on the back of the Caribou. Caribou remained in the area for 3 days and then died.
4	January 1972	Suslositna Creek	Caribou	Unk	Calf	2%	J. Ainesworth	Informant found a Caribou calf recently killed by a Lynx, which leapt from a leaning spruce as the Caribou crossed a frozen pond. The Caribou had been bitten around the head. The Lynx left the Caribou after killing it and never returned. The carcass was later visited by a fox and a Wolverine.
5	1970s	Suslota Lake	Caribou	F	Ad	10%	D. Cramer	Found two adult cow Caribou that had been killed at the same place, but on separate occasions, by an adult male Lynx. The Lynx had jumped off a bank and in one bound reached the Caribou. It appeared the second kill was made after the first was frozen. The Lynx apparently abandoned both carcasses after they became frozen.
6	1975–1976	Koyukuk River near Hughes	Caribou	F	Ad	0%	J. Davis	During aerial Caribou survey a large Lynx was observed sitting next to the intact carcass of an adult cow. Despite a heavy snowfall, the snow adjacent to the carcass showed fresh blood stains and signs of a struggle, indicating the kill was only minutes old.
7	7 November 1982	1.6 km south of Mentasta Lodge	Caribou	Unk	Calf	Unk	G. Maule	Observed a Lynx on the Caribou's back, after which the mortally wounded calf tumbled down a steep slope along a highway. Calf had been clawed and bitten on the head. Lynx proved to be a large male (est. wt. 12.7 kg).

TABLE 2. *Concluded.*

No.	Date	Location	Species	Sex	Age	Approx. amount consumed	Informant	Informant comments
8	29 November 1982	1 km south of Mentasta Lodge	Caribou	M	Calf	2%	This study (R. Stephenson)	Tracks showed that a Lynx had killed the calf after a protracted encounter covering about 400 m, as described in the text. Caribou femur marrow fat = 56%.
9	15 February 1983	Upper Ladue River	Caribou	M	Calf	5%	W. Gramont	Informant found largely intact carcass of a Caribou that had been killed by a Lynx. The Lynx had fed on the neck and part of a shoulder.
10	12 March 1983	West Fork Dennison River	Caribou	M	Calf	60%	This study (D. Garngaard)	A large male Lynx was observed at a Caribou carcass on five occasions between 3/10 and 4/20/83. An inspection on 3/21 showed the Lynx had killed the Caribou 25 m after first making contact with it. The Lynx remained at the kill for at least 42 days, until 4/21 when the river ice thawed and the carcass washed away. Caribou femur marrow = 77%.
11	28 January 1985	Mosquito Park, Fortymile River	Caribou	Unk	Cow and Calf		This study (D. Grangaard)	Tracks showed that a Lynx had followed the Caribou for at least 1 km. At one point the Lynx had run about 30 m, chasing the Caribou, before again following the Caribou at a walk.
12	28 March 1987	Tangleblue Creek, John River	Caribou	Unk	Calf	9%	This study (R. Stephenson)	A large Lynx was observed resting at the carcass of a freshly killed Caribou. Tracks in the snow showed clearly that the Lynx had just killed the Caribou after an attack covering at least 200 m. The Lynx fed on the carcass for several days and had covered the carcass with snow by the second day following the kill. Lynx tracks were also observed at an older Caribou carcass 1 km away.
13	December 1983	Charley River	Dall Sheep	M	Ad	Unk	W. Rimer	Informant was told that a trapper (A. Carol) found a large Dall Sheep ram that had been killed by a Lynx on the upper Charley River. The Lynx, a large male, was trapped at the sheep carcass.
14	17 December 1985	Riley Creek, Denali National Park	Dall Sheep	M	9	1%	This study (J. Burch)	As described in the text, a sheep was found soon after it was killed by a Lynx. Tracks indicated the Lynx had ridden the sheep for at least 30 m before the sheep died. Major wounds were on the dorsal part of the neck behind the head. Sheep femur marrow fat = 70%, age = 9.5 years.

after the attack began. In one case examined by us and in three cases described by informants, major wounds were located on the head, neck, or shoulders of Caribou.

Eight (73%) of 11 known-age Caribou killed by Lynx during 1965-1987 were calves, and three were adult females. The proportion of calves in interior Alaska Caribou herds during winter rarely exceeds 25% (Davis and Valkenburg 1978), suggesting that Lynx may select relatively small Caribou during winter, as well as in summer (Bergerud 1971).

Marrow fat levels in two Caribou calves killed in November 1982 and March 1983 were 56% and 77%, respectively. These are well above levels found in Caribou dying from malnutrition ($\bar{x}$ = 6.5%, range = 5.0-7.8%), and similar to levels measured in Wolf-killed Caribou (which were apparently in good nutritional condition ($\bar{x}$ = 6.4.6%, range = 27.2-96.9%) (Davis and Valkenburg 1978).

We closely examined the scene of successful attacks on a Caribou calf and a Dall Sheep ram within a few hours after the predation occurred, and include here a detailed account of each incident.

On 29 November 1982 we investigated the site at which a Lynx had recently killed a Caribou. Tracks provided a clear record of the attack, which extended over a distance of 400 m. It appeared the Caribou initially became frightened and ran approximately 46 m without being pursued by the Lynx, which continued to stalk along the opposite side of a low ridge parallel to the Caribou. The Caribou stopped, defecated, and then ran directly away from the Lynx. The Lynx pursued it around a lake edge and succeeded in wounding it as it "rode" the Caribou for a distance of about 50 m. The Caribou then bedded down, bleeding, at the lake edge after traveling an additional 90 m, with the Lynx also bedded 9 m away. The Caribou then moved 50 m to a low knoll before again lying down. The Lynx walked around the Caribou at least twice before again attacking, driving the Caribou onto the lake where it was mortally wounded on the neck and began bleeding profusely. After this struggle the Caribou walked 183 m across the lake, with the Lynx following, to a narrow channel between islands, where it died. The Lynx had consumed about 0.5 kg of flesh from the neck.

The scene of a successful attack on a Dall Sheep was inspected on 17 December 1985 within 24 hours after the kill. When discovered, the sheep was lying on creek ice on its sternum with its head down and legs splayed out on either side. The Lynx had eaten less than 1 kg of flesh from an area 20 cm wide along the back of the neck, down to and around the spine. Except for this area, a few abrasions on its forelegs, and areas along the back where Ravens (*Corvus corax*) had begun to feed, the carcass was intact. The tracks of a single Lynx showed it had recently left the carcass.

The total length of the chase is unknown, but a close examination of the last 100 m of the chase showed the Lynx pursued the ram down a steep gully and onto the creek ice, with the Lynx running along the right side of the ram's trail. After traveling 20 m on the creek, the ram had broken through some overflow ice over a 0.5 m deep airpocket. This may have slowed the ram slightly; about 10 m beyond this point tracks showed the Lynx had leaped onto the ram where it remained as the ram attempted to climb a nearly vertical rocky bank. The ram climbed two-thirds of the way up the 20 m bank before turning and angling back down onto the ice where it fell and slid 1-2 m to the point where it died. No blood or hair was found along the path of the chase, and it appeared the Lynx had killed the ram by biting the back of its neck, perhaps injuring its spine.

The kill had occurred within the 24 hours since the area had been visited the day before, and probably occurred less than an hour before it was found, judging by the small amount of snow in the tracks (light snow had fallen all day). A visit to the site on the following day showed the Lynx had returned to feed on the carcass and that foxes and Ravens had also fed extensively. Both front legs had been removed and carried off, and the neck, back, and ribs had been fed upon. The viscera and hindquarters were intact. The head and one femur were collected at this time. By 1030 on 19 December 1985 the carcass was gone, with only hair and rumen contents remaining at the site. Tracks showed that the Lynx, as well as foxes and Ravens, had dismembered the carcass and consumed or carried it away.

Examination of horn annuli showed that the ram was 9.5 years old. Although the femur marrow contained 70% fat, the mandibles showed signs of severe lump jaw (W. E. Heimer, Alaska Department of Fish and Game, personal communication.) Hoof or leg abnormalities were not found.

The cases reviewed here indicate that adult Lynx are quite capable of killing foxes, Caribou, and Dall Sheep. Although no precise measure of observer field effort is available, high fur prices during the past two decades caused a rapid increase in trapping effort that has been, to a large degree, sustained during this period (Alaska Department of Fish and Game, unpublished data). Our records of Lynx predation on alternate prey do, however, suggest that this behavior is most common when Snowshoe Hares are scarce, as has been suggested elsewhere for Lynx (Brand et al. 1976) as well as for Coyotes (*Canis latrans*) (Todd and Keith 1983).

Reported Lynx population densities in North America range from 1 Lynx/5 km^2 (Parker et al. 1983) to 1 Lynx/50 km^2 (Brand et al. 1976) or more depending on the phase of the Snowshoe Hare cycle. When hare populations crash, dense populations of Lynx are left to rely more on other food sources, and it is during this period that Lynx predation would have the greatest effect on populations of animals such as foxes, Caribou, or Dall Sheep. Because of the relatively high densities that Lynx populations can attain, they constitute a potentially significant source of mortality on these, and possibly other, species. The availability of alternate prey during cyclic lows in small game populations may be an important factor allowing some Lynx to survive periods of hare scarcity.

The general observations reported here suggest that Lynx could, at times, contribute to declines in Red Fox populations in Alaska. When Lynx are abundant, their population density can approach that of foxes, which approximates 1 fox/10 km^2 in northern boreal forests (Voigt 1987). Even a small number of foxes killed by individual Lynx could, in aggregate, reduce fox numbers. The observations of numerous trappers in the upper Tanana Valley indicate that fox abundance declined drastically during winter 1982-1983. One trapper reported that a similar phenomenon occurred in the Koyukuk River drainage in western Alaska in the 1930s.

Five of the most experienced trappers we interviewed reported that foxes are usually scarce when Lynx are abundant in local areas. However, it is difficult to know the extent to which this is caused by different habitat preferences of the two species (foxes preferring more open habitat than Lynx), by foxes actively avoiding areas having high Lynx numbers, or by high mortality of foxes from Lynx predation.

The effects of Lynx predation on Caribou and Dall Sheep populations are unknown. The Newfoundland Caribou studied by Bergerud (1971) generally calve in small areas of open muskeg intermixed with forest. In Alaska several major Caribou herds calve on alpine or arctic tundra (Skoog 1968; Hemming 1971). However, Caribou herds in interior Alaska commonly frequent forested and partly forested habitat during and after calving when calves are small and vulnerable (Davis et al. 1978). Lynx predation could, at times, be an important source of mortality for these Caribou. The occurrence of Lynx predation on relatively large prey may be relatively easy to overlook because the predator is small, forest dwelling, unobtrusive, often solitary, and does not dismember and scatter to kill to the same extent as some other predators, such as Wolves. The likelihood that other large carnivores such as Wolves, Wolverines (*Gulo gulo*), or bears (*Ursus* spp.) may usurp Lynx kills, and partly obliterate signs of Lynx presence, would also lessen the chances of identifying Lynx predation as a cause of death. Knowledge of predation on Caribou calves during their first six weeks of life has resulted largely from observations in open areas, where Lynx rarely occur. To date, few Caribou calf mortality studies have employed telemetry or other techniques that would eliminate the bias against locating kills in brushy or forested habitat.

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Survivorship of Overwintering Hatchling Painted Turtles, *Chrysemys picta*, in Northern Idaho

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Thirteen nests in a northern Idaho population of Painted Turtles (*Chrysemys picta*) were followed from oviposition in mid-summer until emergence the following spring. No nest predation was noted in the two years of this study. Overall survivorship for 193 eggs was between 21% and 33%, and survivorship within seven successful nests was between 38% and 60%. Average hatchling size at emergence was positively correlated with female size ($r^2 = 0.929$). First emergence from nests occurred 292-348 days after oviposition, though for only two nests was this period greater than 299 days.

Key Words: Painted Turtle, *Chrysemys picta*, nest survivorship, emergence, Idaho.

Overwintering in the nest by hatchlings has been reported for species in at least six chelonian families (Gibbons and Nelson 1978), including the Painted Turtle (*Chrysemys picta*), a wide-ranging, well-researched North American species. Due to the length of time the eggs and hatchlings remain in the ground, however, only a few studies have included data on natural survival rates of overwintering *C. picta* (Tinkle et al. 1981; Christens and Bider 1987). Estimates of survivorship have also been produced through construction of life tables (Gibbons 1968; Wilbur 1975), while Breitenbach et al. (1984) studied annual variation in total nest failure due to a factor termed winterkill. This paper reports survivorship for 13 nests in a northern Idaho population of *C. picta*, with dates of emergence and relationship of hatchling size to female size.

Study Area and Methods

Hatchling survivorship and emergence was studied at three waste water ponds (46° 45′N, 116° 56′W) associated with a mobile home park situated amid agricultural fields, near Moscow in northern Idaho (*see* Lindeman 1990 for a complete description). Seven nests were located in 1986 and six in 1987 during a general population study (Lindeman 1988) and followed until hatchling emergence. All nests were constructed on patches of bare ground amid grasses and other herbaceous vegetation. Plastron length (PL) of females was measured to the nearest 1 mm with a flexibile plastic ruler and eggs were counted for all 13 nests. For five of the six nests in 1987, egg lengths and widths were measured to the nearest 0.1 mm using Vernier calipers.

In 1986 a sample of nests constructed in June was uncovered on 30 August. Hatching was noted to have occurred, and nests were covered again, without enumeration of live hatchlings. Fenced enclosures were placed around each nest after the ground had thawed the following spring, and nests were checked every evening to determine date of emergence and survivorship within nests. Plastron length of emergent hatchlings was measured to the nearest 1 mm and hatchlings were released outside the enclosure. In March 1988, a max-min temperature probe was placed 5 cm below the ground between two nests that were 1.3 m apart in order to measure soil temperature preceding emergence from the two nests.

Results

None of the 13 known nest sites were disturbed by predators during the course of this study. Emergence in all cases took place in the spring of the year following oviposition.

Hatchlings emerged from seven of 13 nests (54%) (Table 1). In four cases, emergence from a nest was spread over a number of days (range 7-15). Results from two nests were unclear. In April, 1987, hatchlings escaped from one nest due to a faulty enclosure, and in March, 1988, an enclosure was built after emergence had already begun. In both cases, estimates of the maximum number of emergent hatchlings (Table 1) were based on later excavations of nests and examination of egg and hatchling remains.

Excavation in June 1987 of four 1986 nests that had failed completely, and two that had failed partially, showed approximately equal numbers of dry, yolky eggs and partially decomposed hatchling remains. Exact enumeration was not possible due to advanced stages of decomposition. Three live hatchlings were found in one already opened nest (Table 1). The nest of 16 eggs from

TABLE 1. Emergence and survivorship data for 13 nests of *Chrysemys picta*, including the interval between date of oviposition and date of first emergence.

Date of oviposition	N	Female PL (mm)	Emergence dates (# emerging)[1]	Interval (d)	Percent survivorship[1]	Average hatchling PL (mm)
1986			**1987**			
3 June	13	190	17 May (2)	348	15	23.0
3 June	11[2]	183	no emergers	—	0	—
16 June	16[2]	178	7 April (14?)	295	88?	—
19 June	14	177	7 April (2); 7 June (3 live hatchlings excavated)	292	36	22.2
21 June	16	183	no emergers	—	0	—
21 June	15	190	no emergers	—	0	—
23 June	13	163	no emergers	—	0	—
1987			**1988**			
29 May	17	199	23 March (11?); 26 March (2); 30 March (2); 4 April (1)	299	94?	26.4
2 June	15	165	26 March (1); 1 April (1); 2 April (3); 11 April (5); 12 April (1); 13 April (3)	298	93	20.1
13 June	16[2]	193	no emergers	—	0	—
16 June	16	182	3 April (4); 7 April (1); 10 April (1); 11 April (1)	292	44	23.1
17 June	15	173	no emergers	—	0	—
19 June	16	165	29 April (1); 30 April (3); 2 May (1); 5 May (1)	315	38	19.5

[1]Question marks for nests of 16 June 1986 and 29 May 1987 indicate the escape of hatchlings from fenced enclosures surrounding the nests, with estimates of the maximum number emerged and maximum percent survivorship based on later excavation of hatchling and egg remains (see text).

[2]Numbers of eggs in each of these nests represent clutch sizes of 17, with loss of broken eggs or eggs not laid in the nest.

which hatchlings had apparently escaped on 7 April was also excavated in June, 1987, and contained a large quantity of broken eggshells and two unopened eggs that contained decomposing remains. It is thus possible that this nest was 88% successful, if it is assumed that up to 14 of 16 eggs may have produced emergent hatchlings.

The initial number of emergent hatchlings on 23 March 1988 from a nest of 17 eggs may have been as high as 11, since five later emerged after an enclosure had been put in place, and subsequent excavation turned up one yolky, unopened egg, and several empty eggshell fragments. Other excavations in 1988 were conducted earlier than in 1987 to allow enumeration of remains; however, not all eggs originally laid could be accounted for as emergent hatchlings or remains (Table 2). Data from Tinkle et al. (1981) also suggest that

TABLE 2. Results of excavations of nests after emergence was completed in 1988 (YE = yolky eggs, ER = embryonic remains partially or fully encased in egg shells, DH = dead hatchlings, SF = shell fragments). Percent found is the percent of eggs not producing hatchlings that were accounted for at excavation.

Eggs laid	Emergent hatchlings	Found upon excavation	Number not accounted for	Percent found
17	6-16[1]	1 YE, SF	?	?
15	14	SF	1	0
16	0	SF	16	0
16	7	4 YE, 3 ER, 1 DH, SF	1	88
15	0	15 YE	0	100
16	6	2 YE, 3 ER, 1 DH, SF	4	60

[1]Number not known exactly (see text).

excavation of nests after emergence has been completed is not a reliable method for determining the number of hatchlings that have emerged or the fate of all eggs originally laid.

The two cases of unenumerated hatchling emergence noted above thus indicate the emergence of anywhere from two (one from each nest) to 25 (11 + 14) live hatchlings. Overall success was therefore between 21% and 33% for all 193 eggs, and between 38% and 60% for the seven nests that produced one or more emergent hatchlings.

Average hatchling PL at emergence was 21.8 mm (range 19-27 mm, SD = 2.32 mm, $N = 39$). Average hatchling PL within a nest was positively correlated to female PL ($r = 0.96$, $P < 0.01$, $N = 6$) (Figure 1), average egg length ($r = 0.997$, $P < 0.01$, $N = 4$), and average egg width ($r = 0.999$, $P < 0.01$, $N = 4$). There was no significant correlation between average hatchling PL and clutch size ($r = 0.26$, $P > 0.50$, $N = 6$).

The average period between oviposition and first incidence of hatchling emergence was 306 days (range 292-348 days, SD = 20.3 days, $N = 7$ nests). First emergence from five of the seven nests occurred within the range of 292-299 days (Table 1). Minimum and maximum soil temperatures were 3 and 7°C, respectively, for the day preceding first emergence from a nest on 26 March 1988, and 8 and 13°C for a nest from which hatchlings first emerged on 29 April 1988. Average minima and maxima, all dates of emergence considered for each nest (Table 1), were 2.9°C (range: -1.0 to 5.0°C) and 16.4°C (7.0 to 22.5°C) for the former, and 2.5°C (-1.0 to 6.0°C) and 12.6°C (11.0 to 15.0°C) for the latter.

Discussion

Survivorship of *C. picta* from egg laying to emergence was 21-33% for a population that

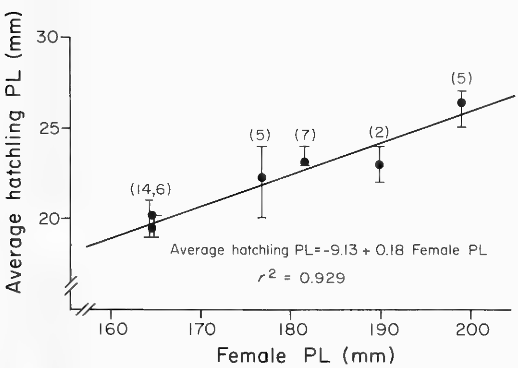

FIGURE 1. The relationship between average hatchling PL at emergence and female PL. Ranges are indicated by brackets, and sample sizes of hatchlings are in parentheses.

appears to be free of vertebrate predators, a highly unusual situation for this species (Blanchard 1923; Christens and Bider 1987; Gemmell 1970; Gibbons 1968; Snow 1982; Tinkle et al. 1981; Wilbur 1975). Christens and Bider (1987) estimated survivorship at 24% for a population in Quebec, but that figure included predation responsible for the complete loss of 44% of all nests. Discounting these nests, hatchlings emerged from five of nine remaining nests (56%), nearly identical to the figure reported here (54%), although the success rate within those nests was higher (92%, as opposed to 38-60% reported here). Tinkle et al. (1981) found that 21% of nests in a Michigan population were lost to predators, and 12% to other causes, but did not give data on percent survivorship within the 67% of nests which produced hatchlings. Estimates of survivorship between egg laying and hatchling recruitment from life table studies in Michigan (Gibbons 1968, 2%; Wilbur 1975, 8%) are lower than the above estimates from field observations of hatching success. This may suggest additional high mortality immediately after hatchlings enter the aquatic habitat, before they begin to be captured during field sampling efforts involving the entire population.

It is not known how, or if, temperature influences the timing of emergence by turtle hatchlings overwintering in the nest. Bleakney (1963) hypothesized that reversed soil temperature gradients in the spring might act as a cue for hatchling emergence in overwintering turtles. Such a response could occur over a wide range of soil temperatures. Soil temperature at emergence from seven Michigan nests of *C. picta* ranged from 12.9 to 19.9°C (Breitenbach et al. 1984); emergence of at least some hatchlings from two nests in this study occurred at temperatures below this range. Additionally, emergence of two hatchlings from another nest on 30 March, 1988, occurred while 2-3 cm of lingering snow cover from a late winter snowfall was melting but still on the ground. The number of days between oviposition and first hatchling emergence (Table 1) showed a surprising consistency for five of seven nests, raising the possibility that some sort of endogenous timing mechanism may also be involved in cuing emergence. Such a timing mechanism, although purely speculative at this point, would be selected for if it delayed emergence until a time when rising soil temperatures could be predicted to remain high, so that hatchlings would not emerge in mid-winter during occasional short periods of warm weather.

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Effects of Drought on American Coot, *Fulica americana*, Reproduction in Saskatchewan Parklands

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The effects of drought on reproduction of American Coots (*Fulica americana*) were studied in 1981 and 1982 in south-central Saskatchewan. Drought greatly reduced coot nesting habitat, and pair densities decreased to about 10% of those recorded in the same area during wetter years. In 1981, the first year of the drought, 16 of 28 (57.1%) nests were depredated and many young were lost as ponds became dry before young fledged. In 1982, 39 of 83 (47.0%) nests were depredated but no young were lost to pond drying. Brood survival was related to pond water depth and height of emergent vegetation. Productivity was 0.8 and 0.9 young per pair in 1981 and 1982, respectively. These levels of nest and brood survival are among the lowest recorded for the American Coot.

Key Words: American Coot, *Fulica americana*, breeding biology, drought, Saskatchewan.

Many studies have documented the deleterious effects of drought in marsh-nesting birds, but few have included information on American Coots (*Fulica americana*). Weller et al. (1958) noted that coot populations in a small Utah marsh decreased through loss of nesting vegetation caused by low water levels. Krapu et al. (1970) examined the effects of decreasing water levels on coots in northwestern Iowa and found that population size, nesting effort, and production of young decreased with drier conditions.

In 1981 and 1982, I studied American Coot habitat selection and reproductive ecology in south-central Saskatchewan. Drought conditions prevailed during the study, providing an opportunity to examine its effects on breeding coots. This was aided by a previous study of habitat use by breeding coots in the same general area during normal and above-normal water levels (Sugden 1979).

To increase our understanding of the effects of drought on breeding coots, this paper relates quantitative habitat variables to coot reproductive success under drought conditions and discusses the results in relation to habitat selection in this species.

Study Area and Methods

The study area was in aspen parkland, approximately 48 km east of Saskatoon, Saskatchewan (52° 10′N, 105° 50′W) (Figure 1). Topography is rolling to gently rolling, and isolated Trembling Aspen (*Populus tremuloides*) patches are interspersed amongst the cropland. Emergent vegetation species in ponds used by nesting coots in order of decreasing frequency were bulrush (*Scirpus* spp.), Common Cattail (*Typha latifolia*), Awned Sedge (*Carex atherodes*), and Spangletop (*Scolochloa festucacea*).

In 1981, the southern half of the study area was searched and two transects totaling 48.3 km (15 ponds) were used. In 1982, the entire area was searched and two transects totaling 42.9 km were added for a total of 91.2 km (27 ponds). The transects followed roads and were situated to sample the maximum amount of pond habitat. Only ponds less than 400 m from a road were eligible. Because coots invariably nest in flooded emergent vegetation, only ponds containing such cover were studied.

Pond water levels were monitored using depth markers from late April through early September. Pond depths were measured in early September. Ponds were classified using permanency categories described by Evans and Black (1956). Type 1 (temporary) ponds always dry by mid-summer, whereas type 3 (seasonal) ponds often have water at this time. Type 4 (semi-permanent) ponds have water throughout the season in most years, and type 5 (permanent) ponds usually retain water. Areas of ponds were determined from photomaps using a digitizer.

Nest searches were conducted at two-week intervals from approximately 1 May to 10 July. Nests were marked with a 1.2-m lath placed about 3 m distant. Renests were identified by their proximity to recently destroyed first nests. Nests were visited one to three times per week until hatching. A nest was recorded as successful if at least one egg hatched.

Habitat variables measured at nests were: water depth (± 0.01 m), distance to open water (± 0.5 m), distance to shore (± 0.5 m), emergent zone width (± 0.5 m), vegetation density, and vegetation height (± 0.2 m). Nest water depths were adjusted to the estimated initiation date using the water loss rate for each pond. Distance to open

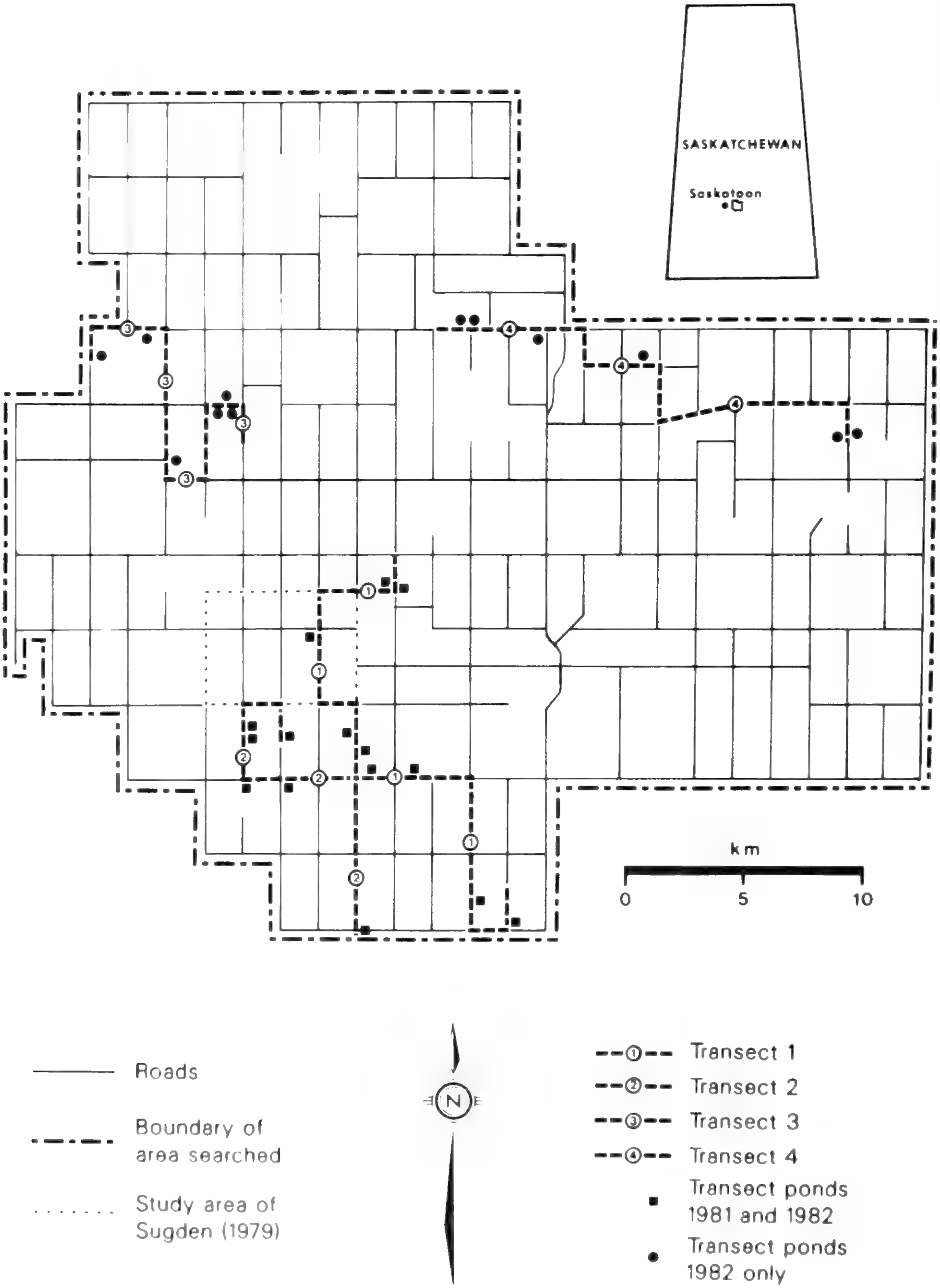

FIGURE 1. Study area, approximately 48 km east of Saskatoon, Saskatchewan.

water was defined as the distance between the nest and the nearest point where a coot would have unobstructed access to open water. Emergent zone width was the distance between open water and shoreline at the nest. Vegetation density was measured using a board adapted from the design of Nudds (1977). The board was placed 1 m from the nest in the four directions parallel and perpendicular to the shoreline. Vegetation density was read by observing the board from the nest and was

recorded as one of six cover categories for each 0.2-m height class: 0%, 1-20%, 21-40%, 41-60%, 61-80%, 81-100%. Only vegetation measurements taken within three weeks of the clutch initiation date were used, and they were averaged for the analysis. Over 75% of the vegetation data were collected within two weeks of clutch initiation.

Coots were nest-trapped to estimate the age structure of the population. Traps were set between 00:00 and 04:00 (Crawford 1977) and aging was based on the tarsal color scheme of Crawford (1978). Brood counts were made in early and late July and late August from a floating blind entered before dawn. Counts were also made in August 1982 from blinds on shore.

Statistical tests were performed using SPSS (Nie et al. 1975) except for paired t-tests which were completed using Biomedical Computer Programs (Dixon and Brown 1979). Tests with probabilities > 5% were considered non-significant. Arcsine transformation (Sokal and Rohlf 1981) was used on vegetation density data for analysis.

Precipitation records for September 1980 to August 1982 were from annual meteorological summaries at Saskatoon (Canadian Atmospheric Environment Service 1980, 1981, 1982). Below average precipitation during the seven months preceding the 1981 and 1982 nesting seasons was the primary cause of low water levels. Although there was above average rainfall in April 1981 and May 1982, it did not counteract the effects of low precipitation during the previous winter.

Results and Discussion

Pond use

Coots nested exclusively in types 4 and 5 ponds that contained flooded emergent vegetation during early May. The narrowest emergent zone width used for nesting was 3.5 m. Types 1 and 3 ponds lacked emergent vegetation or became dry early in the nesting season and were not used by nesting coots.

Pair densities in 1981 and 1982 were 0.14 and 0.10 pairs/km^2, respectively, using only the area searched. Sugden (1979) reported pair densities of 13.6, 17.8, and 32.6 pairs/km^2 for 1973-1975, respectively, on a 31.1-km^2 block in the same area as this study (Figure 1) during a period of relatively high water levels. The large differences in pair density between the two studies can be attributed to: (1) Sugden's area had a higher basin density as potential coot nesting habitat, and (2) most of the type 3 and 4 ponds on my transects that were similar to those studied by Sugden were dry or nearly dry because of the drought.

I compared pond area per nest in this study with that from Sugden (1979) (Table 1). Unlike Sugden's ponds, many of the ponds I studied had large areas of open water, which contributed to a larger pond area per nest. My types 4 and 5 ponds had more open water than Sugden's ponds because all of the smaller ponds of these two types on my transects were unsuitable for coot nesting due to the drought. Coots did not use type 4 ponds in 1982

TABLE 1. Pond use by nesting American Coots.

Year	Pond type	Percent of all nests	Mean pond area (ha/nest) All nest ponds	> 1-nest ponds	1-nest ponds
1981	3	0	-	-	-
	4	50	0.67	0.35	1.48
	5	50	0.99	0.85	1.82
	Total	100	0.83	0.62	1.59
1982	3	0	-	-	-
	4	0	-	-	-
	5	100	0.72[a]	0.72	1.11
	Total	100	0.72	0.72	1.11
1981-82	3	0 (5)[b]	- (0.34)	- (0.47)	- (0.31)
	4	20 (36)	0.67 (0.33)	0.35 (0.33)	1.48 (0.34)
	5	80 (59)	0.78 (0.38)	0.74 (0.35)	1.58 (0.59)
	Total	100 (100)	0.79 (0.36)	0.69 (0.34)	1.52 (0.41)

[a]As there were 55 nests on > 1-nest ponds and only one nest on a 1-nest pond in 1982, the value of 1.11 ha/nest for the only 1-nest pond did not raise the mean for all nest ponds above 0.72 ha/nest.
[b]Data collected in 1973-1975 after Sugden (1979).

as these ponds had poor development of emergents or became dry.

My 1-nest ponds were considerably larger than the mean 1-nest pond areas of 0.34 and 0.59 ha for types 4 and 5 ponds reported by Sugden (Table 1). Five of the seven 1-nest ponds I studied had areas greater than 1.0 ha. The difference in size of 1-nest ponds between the two studies was caused primarily by the lack of permanent water in the smaller ponds.

In 1982, nesting occurred on only one of the 12 ponds used in 1981. I compared water depths on 1 May of the remaining 11 ponds between 1981 and 1982. All ponds were deeper in 1981 than in 1982. Mean depth in 1981 was 62.7 cm compared to 58.5 cm in 1982 ($t = 11.9$, $df = 10$, $P < 0.0001$, paired t-test). Although the mean water depth difference between years was small (4.2 cm), the availability of flooded emergents for nesting was markedly affected. Water levels in these ponds in late April 1982 were at the inside edge of the bordering dead emergents, and new growth was left dry as the shoreline receded. The twice normal precipitation in May 1982 (83 mm) did not counteract this.

Kiel (1955), Smith (1971), and Sugden (1979) observed that coots rarely nested on ponds that became dry before the young could have fledged. Sugden (1979) found that only 2 of 1991 (0.001%) nests during 1973-1975 were on such ponds. His observations were made during a period of average to high water levels. In my study, 12 of 26 (46.2%) nesting attempts in 1981 and none of 56 first and 22 second nesting attempts in 1982 were on ponds which dried before fledging was possible (Sutherland and Maher 1987). It appears that the ability of coots to select ponds that retain water during the breeding season is overstated, at least during the initial stage of a drought. Weller and Spatcher (1965) also found that coots did not seem to recognize habitat inadequacies, and Gorenzel et al. (1981) reported that coots may not abandon a nesting area immediately if there is deterioration of habitat after nest initiation. However, these views contrast with Smith (1971: 28), who believed that coots would bypass previously used habitat even before drought conditions became evident.

Thirty-five coots were trapped or found dead on 34 nests. Twenty-two (63%) were yearlings, 10 (28%) were two-year-olds and 3 (9%) were at least three years old. All of the coots older than one year were on type 5 ponds. Crawford (1980) estimated that of 352 breeding coots, 45% were yearlings, 31% were two-year-olds, 18% were three-year-olds and 6% were at least four years old. It would appear that my population was younger than that studied by Crawford.

Thirteen of fourteen nest-trapped coots in 1981 were yearlings. Ryder (1963) reported that a newly-fledged coot has a life expectancy of between two and three years. With such a short life span, the costs and benefits of early breeding in poor habitat might outweigh the risk of deferred breeding. This is probably the reason that coots pioneer areas so rapidly (Weller and Fredrickson 1973).

Nest success

Nest success varied from 31.8 to 37.7% (Table 2). Most nest losses were attributed to predation by American Crows (*Corvus brachyrhynchos*) and Black-billed Magpies (*Pica pica*). Desertion was a major source of nest loss in 1982. Seven nests were discovered after they had been depredated.

I compared the percentage of nests hatching on each pond versus the corresponding values of mean nest water depth, pond water loss rate, and pond depth on 1 May of the respective year. Using only first nests, there were no significant regressions. When single nesting attempts and renests were used (pair success), there was a

TABLE 2. Fate of American Coot nests.

Nest fate	1981	Percent	1982 first nests	Percent	1982 renests	Percent
Successful	10	35.7	23	37.7	7	31.8
Deserted	0	0.0	8	13.1	2	9.1
Depredated						
Corvid	15	53.6	23	37.7	13	59.1
Owl	0	0.0	3[a]	4.9	0	0.0
Muskrat	1	3.6	0	0.0	0	0.0
Deserted and depredated[b]	2	7.1	4	6.6	0	0.0
Total	28	100.0	61	100.0	22	100.0

[a]One adult for each nest taken by Great Horned Owl (*Bubo virginianus*), eggs of two of these nests were depredated by corvids.

[b]Nests for which desertion was confirmed before predation.

significant regression of percent nests hatched on each pond (Y, in %) versus mean nest water depth (X, in cm): $Y = 2.12X - 30.16$, $r = 0.42$, $P < 0.04$.

Nest success in this study was very low in comparison to previous studies (Table 3). The nest success of 41% noted by Anderson (1957) is the only value similar to that observed in this study. Over half of the nests in Anderson's study were depredated. In most studies, high nest success was due to low rates of desertion and predation. Many authors attributed the low nest loss to low predator densities, good habitat conditions, or abundant alternative food available to predators.

Brood survival

Reliable brood counts were obtained for all ponds in 1981 and for five of nine ponds in 1982. The number of young fledging from the remaining nests in 1982 could not be determined because of dense emergent vegetation and the breakdown of territoriality as the young matured. The number of coot young produced per nest in this study was lower than that reported in other studies (Table 3).

Values for nest variables and pond water depths among three groups of nests reflect coot nesting habitat requirements (Table 4). Minimum values and means were generally larger for class 2 and class 3 nests, although only pond water depth and vegetation height differed significantly ($P < 0.01$). The mean maximum pond water depth for class 1 nests was less ($P < 0.01$) than the corresponding values for the other two groups. Thus, it appears that young will not fledge on ponds with a spring depth less than about 0.5 m. However, this is contingent on the amount of rainfall during the breeding season. The differences in vegetation height between groups were probably the result of taller vegetation on the deeper and more permanent ponds.

Pond drying would cause reproductive failure because of: (1) desertion of young by adults, (2) increased exposure to predators, and (3) reduced food availability. As no coots in my study were observed for several weeks before the ponds dried, the young were probably deserted by the adults. Movement of adults and young to an adjacent pond was unlikely as it was at least 4 km to a pond with sufficient cover. Smith (1971: 28) did not observe any territorial coot pair leave a pond in response to drought.

Coot breeding success in this study was low even when the effects of nest predation were removed. An average of 0.9 young were produced for every nest, whereas 2.0 young fledged from each successful nest. Nest desertion and predation were the primary causes of reproductive failure in both years. Young were lost to pond drying in 1981 only. Low breeding success was also reported by Sooter (1942) and Gullion (1954), who found that about two young were produced for all nests. Other studies reported a minimum of 4.8 young fledging per nest. Henny et al. (1970) calculated that each coot pair would have to fledge about 6.5 young per year to maintain a stable population size. Crawford (1980) believed this figure was probably too high, as they ignored age-specific recruitment rates. Without immigration, an improvement in habitat conditions, or increased hatching success,

TABLE 3. American Coot breeding success.

Number of nests	Nest success (%)	Young per nest[a]	Location	Reference
111	36.0	0.9	Saskatchewan	Present study
105	41.0	-	California	Anderson (1957)
16	68.8	1.9[b]	California	Gullion (1954)
451	80.3	2.0 (347)[c]	Iowa	Sooter (1942)
161	86.0	-	Iowa	Fredrickson (1967)
330	89.0[d]	-	Colorado	Gorenzel et al. (1982)
35	-	4.8[e]	Iowa	Crawford (1980)
318	91.2	5.2[b,c] (48)	Utah	Ryder (1961)
110	92.7	-	Washington	Fitzner et al. (1980)
149	94.6	4.9[e] (194)	California	Miller (1953)
188	94.7	5.8	South Dakota	Vaa et al. (1974)
163	96.9	-	California	Hunt and Naylor (1955)
380	97.0	-	Manitoba	Kiel (1955)

[a]Young counted when 4-6 weeks old, unsuccessful nests included in calculations unless noted otherwise.
[b]Includes second broods.
[c]Number of nests.
[d]Mayfield (1975) method known to be used.
[e]Unsuccessful nests excluded.

TABLE 4. Comparison of pond water depths and variables measured for three groups of American Coot nests.

	Class 1 nests[a] (n = 12 (5)[e])			Class 2 nests[b] (n = 61 (17))			Class 3 nests[c] (n = 18 (8))			Significance of Duncan's statistic[d]
	Min	Mean	SD	Min	Mean	SD	Min	Mean	SD	
Pond depth (m)[f]	0.26	0.47	0.13	0.39	0.73	0.26	0.39	0.86	0.31	A** C**
Nest water depth (m)	0.15	0.30	0.09	0.13	0.32	0.09	0.20	0.32	0.08	
Distance to open water (m)	0.5	0.8	0.4	0.5	1.6	1.9	0.5	1.9	1.4	
Distance to shore (m)	2.0	9.1	4.3	2.5	11.0	7.4	3.0	10.5	7.1	
Emergent zone width (m)	3.5	11.5	4.7	3.5	14.3	9.3	3.5	13.3	7.9	
Vegetation density (%)	23.6	50.1	12.4	26.6	51.9	9.0	36.9	53.8	7.3	
Vegetation height (m)	0.3	0.55	0.12	0.3	0.69	0.19	0.6	0.86	0.14	A** B** C**

[a] Ponds which became dry before fledging was possible.
[b] Ponds that retained water but no young fledged. Lowest depth of these ponds on 31 August was 0.20 m.
[c] Young present in late August.
[d] A = statistical comparison of means of groups 1 and 2; B = statistical comparison of means of groups 2 and 3; C = statistical comparison of means of groups 1 and 3;
** $P < 0.01$.
[e] Number of ponds.
[f] Pond depth at mean nest initiation date.

the population of my study would not sustain itself for more than a few years.

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Notes

A Note on the Microdistribution of the Red-backed Vole, *Clethrionomys gapperi*, in the E.N. Huyck Preserve, New York

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Stewart, Craig A. 1991. A note on the microdistribution of the Red-backed Vole, *Clethrionomys gapperi*, in the E. N. Huyck Preserve, New York. Canadian Field-Naturalist 105(2): 274–275.

In a trapping study of small mammals on the E. N. Huyck Preserve (Rensselaerville, New York) it was found that *Clethrionomys gapperi* was captured only in the immediate vicinity of abandoned stone fences. *Peromyscus leucopus* were common throughout the study area. Captures of *P. leucopus* did not seem related to the presence or absence of abandoned stone fences. Thus, interspecific interactions seem unlikely to restrict *C. gapperi* to the areas near abandoned stone fences. The latter may provide essential nesting habitat or protection from predators for Red-backed Voles.

Key Words: Red-backed Vole, *Clethrionomys gapperi*, microdistribution, stone fences, New York.

The Red-backed Vole, *Clethrionomys gapperi*, is a small woodland rodent found in the Northern United States and Canada. Getz (1968) and Miller and Getz (1972, 1973) reported that the microdistribution of this species is influenced by many factors: water availability, vegetation, and interspecific interactions with other small mammal species.

This note reports the results of a trapping study of small mammals which yielded data on the local distribution of *C. gapperi* in relation to the White-footed Mouse, *Peromyscus leucopus*.

a Small mammals were trapped on the E. N. Huyck Preserve, located in the Adirondacks region of New York (in Rensselaerville) between 17 and 23 October 1982. Museum Special traps were spaced approximately 10 m apart on lines run in several predominantly second-growth deciduous woodland areas of the Preserve. Some of the areas contain abandoned stone fences left from early attempts to cultivate the area.

Traps were baited with peanut butter and oatmeal, and were checked at least three times per day. The trapping procedures complied with the methods approved by the American Society of Mammalogists (Ad hoc Committee on Acceptable Field Methods in Mammalogy 1987). The characteristics of each trap station (including type of trees located nearby, presence of stumps, and presence of abandoned stone fences) were recorded to allow for analysis of small mammal microdistribution.

Eighty-nine *P. leucopus*, 12 *C. gapperi*, five shrews, *Blarina brevicauda*, and three deer mice, *Peromyscus maniculatus*, were captured in a total of 879 trap nights. Ten of the 12 *C. gapperi* captured were trapped within one meter, and two within two meters, of an abandoned stone fence. The relationship between capture of *C. gapperi* and the presence of a stone fence within one meter of the trap site was statistically significant ($p < 0.01$, Chi-square test). In contrast, capture of *P. leucopus* was not statistically significantly related to the presence of a stone fence. Traps within one meter of a stone fence accounted for slightly more than 10% of the trap nights. These trap stations were found in a variety of different habitats. Other factors, such as the type of trees near trapping sites, did not have any discernible influence on the capture of either species.

Stone fences have been noted previously as one of several preferred microhabitats of *C. gapperi* (Miller and Getz 1972, 1973). However, in my study area, *C. gapperi* was found only in the immediate vicinity of abandoned stone fences. Since the presence or absence of a stone fence near a trapping site did not affect the chances of capturing *P. leucopus*, it seems unlikely that interspecific interactions were responsible for restricting *C. gapperi* to the vicinity of the stone fences. Instead, the latter may provide essential nesting habitat or protection from predators for the Red-backed Voles.

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Habitat Use by Snowshoe Hares, *Lepus americanus*, in Relation to Pelage Color

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Litvaitis, John A. 1991. Habitat use by Snowshoe Hares, *Lepus americanus*, in relation to pelage color. Canadian Field-Naturalist 105(2): 275–277.

Habitat use by Snowshoe Hares (*Lepus americanus*) was examined in relation to pelage color during vernal and autumnal molting periods. During periods with no snow, mottled and white hares ($\leq 75\%$ brown pelage) occupied sites with more understory cover than brown hares in two of six comparisons. Age and sex-related differences in habitat use did not explain these differences. Because the combined length of the vernal and autumnal molting periods is approximately 140 days, an ability of hares to occupy habitat in response to pelage color differences may have implications to predator avoidance and survival.

Key Words: Snowshoe Hare, *Lepus americanus*, habitat use, Maine, molt, pelage.

Like several other boreal vertebrates, Snowshoe Hares (*Lepus americanus*) undergo vernal and autumnal molts that result in predominantly brown and white pelages, respectively. Because of these molts, a Snowshoe Hare generally blends with the prevailing tone of its environment in any season. However, during the molting period, a population of hares includes members that are brown, mottled, or white (Grange 1932; Severaid 1942). I compared pelage color of hares to habitat features at capture sites during spring and autumn molting periods to determine if habitat use varied with pelage color.

Study Area and Methods

Habitat use of hares was studied in eastern (Cherryfield, 44°35′N, 67°55′W) and western (Pierce Pond, 45°15′N, 70°10′W) Maine, during 1981-1983. Cherryfield was located in coastal Maine and overstory vegetation of this area was predominantly hardwoods, including Red Maple (*Acer rubrum*), Gray and Paper birch (*Betula populifolia, b. papyrifera*), and aspen (*Populus tremuloides, P. grandidentata*). Understory vegetation included Canadian Rhododendron (*Rhododendron canadense*), alder (*Alnus* spp.), and willow (*Salix* spp.). Pierce Pond was located approximately 190 km west of Cherryfield in the mountainous portion of Maine. Dominant overstory species included Red Spruce (*Picea rubrens*), Balsam Fir (*Abies balsamea*), Paper Birch, and Yellow Birch (*B. alleghaniensis*). Extensive logging in this area resulted in dense stands of regenerating spruce and fir. Single-door box traps ($90 \times 30 \times 30$ cm) were placed at 100-m intervals in a 7×7 grid on two sites in each study area (Cherryfield: Lawrence Creek, Pork Brook; Pierce Pond: Alder Road, Otter Pond). Grids within each study area were separated by at least 6 km, preventing hares from occupying more than one sampling grid. Traps were baited with alfalfa pellets and set for 8-15 days during spring (April-May) and autumn (October-November). At the initial capture, each hare was marked with unique

ear tags prior to recording sex, weight, and right hind-foot length. At this and all subsequent captures of an individual, the amount of the hare's pelage that was brown was ranked from 1 to 5 (where: 1 = ≤ 10, 2 = 11-25, 3 = 26-50, 4 = 51-75, 5 = > 75% brown). All captured hares were classified as: white (≤ 25% brown pelage), mottled (26-75% brown), or brown (> 75% brown). I considered white and mottled hares to be more visible to predators because snow was essentially absent during the trapping periods. Although captures of hares were considered independent, the number of captures per individual during a trapping period was limited to three to avoid skewing the results in response to a few individuals captured many times. Therefore, if a hare was captured more than three times during a trapping period, three captures were randomly selected and the rest were deleted from the data set.

Because understory cover is a major habitat feature influencing survival (and visibility) of hares (Wolff 1980; Litvaitis et al. 1985), I compared the distribution of hares by pelage class to an index of understory cover. During the period when deciduous leaves were absent, an observer viewed a vegetation profile board (Nudds 1977) from 15 m east and west of the capture site. A rank of visual obstruction (1 to 5, where: 1 = ≤ 20% and 5 = > 80% coverage) was recorded for each of three strata (0.5-1.0, 1.0-1.5, and 1.5-2.0 m above ground level) (Litvaitis et al. 1985) and the sum of those six ranks (6-30) was used as an index of understory cover. The influence of pelage color on habitat use by hares was examined using an analysis of variance procedure that was compatible with the ranked data (GLM procedure, SAS 1985), and a Wilcoxon two-sample rank comparison (SAS 1985). Statistical significance was assigned at the 0.05 probability level.

Results

Because few hares were captured on the Pork Brook grid (< 20 captures/sampling period), no comparisons were made using the data from that grid. A total of 436 hares were captured 1096 times on the three remaining grids during the four trapping periods. I combined capture sites of mottled and white because hares with white pelages represented only 8.4% of the captures.

A three-factor analysis of variance of the pooled data indicated that understory cover at capture sites varied with pelage color ($F = 13.84$, $P < 0.002$), grid ($F = 30.71$, $P < 0.001$), and season ($F = 6.12$, $P < 0.01$). Therefore, to evaluate further the relationships between pelage color and habitat use by hares, I compared understory cover at capture sites of hares on each grid during spring and autumn. Cover was greater at capture sites of mottled and white hares on the Alder Road grid during spring ($Z = 2.33$, $P = 0.02$) and on the Otter Pond grid during autumn ($Z = -2.63$, $P = 0.01$) (Table 1). Mottled and white hares tended to occupy areas with more cover than brown hares in the remaining four comparisons (Table 1); however, the indices of understory cover were not different.

Discussion

Although these results do not provide strong evidence that hares shift habitat-use patterns in response to pelage color changes, they do warrant further examination. Several factors may have partly contributed to the observed differences in habitat use, including microclimate selection, age or sex-related differences in habitat use that were linked to pelage molting, and predator avoidance. During a period with only patches of snow, Grande (1932) observed white hares moving quickly from snow patch to snow patch. He suggested that this

TABLE 1. Mean ranks of understory cover[a] at captures sites of brown and mottled or white Snowshoe Hares during vernal and autumnal molts.

	Grid					
	Lawrence Creek		Alder Road		Otter Pond	
Season	Brown	Mottled/White	Brown	Mottled/White	Brown	Mottled/White
Spring	17.2	18.5	16.9	20.0*	21.0	21.7
	(77,20)[b]		(104,64)		(172,124)	
Autumn	18.5	20.6	17.5	18.4	21.7	24.5*
	(67,38)		(43,46)		(82,154)	

[a]Ranks of understory cover ranged from 6-30, see text for a description of this variable.
[b]Captures of brown and mottled or white hares.
*Understory cover was greater at capture sites of mottled or white hares than at capture sites of brown hares (Wilcoxon two-sample rank comparison, $P < 0.01$).

response may have been the selection of a cool microclimate by hares, not the selection of a background color to match their coat. Hart et al. (1965) also found that the insulative capacity of the fur of Snowshoe Hares was 27% greater in winter (white pelage) than in summer. However, it seems unlikely that heat stress could explain why white hares tended to select sites with more cover (more shade) during my study because the temperatures during the study period never approached the upper critical temperature of Snowshoe Hares ($\geq 40°$C, estimated from Figure 4 of Hart et al. 1965).

Age or sex-related differences in habitat use that coincided with differences in pelage molting patterns of Snowshoe Hares provides a more likely explanation. Severaid (1942) indicated that juvenile hares molted later than adults. Therefore, if the majority of white hares were adults and the majority of brown hares were juveniles, age may explain why brown hares were located in more open understories because juveniles may be forced into less suitable areas by socially dominant adults (Dolbeer and Clark 1975). In addition, male and female hares may occupy different microhabitats (Litvaitis 1990).

To examine the influence of age and sex of hares on habitat use, I used a three-factor (age, color, sex) analysis of variance. Juveniles were classified as having a right hind-foot length of ≤ 12.5 cm. This was the average hind-foot length of captive hares 13-weeks old, as observed by Severaid (1942). I examined only the two trials where understory use was significantly different between brown and mottled or white hares (Table 1) and found that age, sex, and the interactions of color*age and color*sex did not influence the selection of understory cover.

Are the differences in habitat use among different colored hares a response to their different visibilities to predators? The combined length of the vernal and autumnal molting periods is approximately 140 days (Severaid 1942). Therefore, the ability of a hare to assess its relative visbility to predators and occupy areas with more cover as its visibility increases would have obvious survival advantages if pelage color influenced vulnerability to predation. But the influence of pelage color on the vulnerability of hares to predators is not known. Although the data presented here are not conclusive, they do suggest that hares may respond to short-term changes in pelage color and visibility by occupying sites with more cover. Future research on this topic should also consider the survival rates of hares during the molting period to examine the role of predation and differential vulnerability of molting hares.

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House Sparrow, *Passer domesticus*, Flock Size in Relation to the Proximity of Merlin, *Falco columbarius*, Nests

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Sodhi, Navjot S. 1991. House Sparrow, *Passer domesticus*, flock size in relation to the proximity of Merlin, *Falco columbarius*, nests. Canadian Field-Naturalist 105(2): 278–279.

I recorded House Sparrow flock size at 0, 50, 250, and 450 m from 11 Merlin nests. I found that although smaller flocks (1–5 individuals) occurred more frequently than larger flocks at every distance from the Merlin nests, larger flocks (> 5 individuals) occurred significantly less frequently near the Merlin nests. Large flocks near the Merlin nests may increase likelihood of detection by the Merlins.

Key Words: Merlin, *Falco columbarius*, House Sparrow, *Passer domesticus*, Saskatoon.

The advantages of avian flocking in predator avoidance have been of interest in recent years (Elgar 1989). While counting birds at different distances from Merlin (*Falco columbarius*) nests in Saskatoon (52°07′N, 106°38′W), Saskatchewan, I noted the sizes of House Sparrow (*Passer domesticus*) flocks. House Sparrows form about 70% of the breeding season diet of Merlins in the city (Oliphant and McTaggart 1977, Sodhi unpubl. data). An ongoing study of radio tracking of nesting Merlins revealed that Merlin kill-sites ranged from 10 m to 13 km from the nests. As at least one adult Merlin was present at almost all times near or at each nest, I assumed that House Sparrows should behave in a way that decreases their vulnerability to predation while near Merlin nests.

The sparrow counts were made between 11 May and 23 July 1987 at 11 Merlin nests. Sixty-four counts were made at each of four distances, viz. 0, 50, 250, and 450 m from each nest. The counts were made twice a month at each nest, except two nests where I could not repeat counts in July because the Merlins left the sites. I recorded sparrows for 7 min within 25 m of each point. Individuals within half a meter of each other were presumed to be flocking. Birds in cover within 25 m were counted after flushing. All surveys were made in the first four hours after sunrise and in fair weather (no or ≤ 10% cloud cover and wind speed ≤ 13 km/h). I did not measure vegetation at different points, but examined aerial photographs taken in 1986 and found little difference in the number of trees within 450 m of the studied nests. Moreover, indirect evidence suggests that near Merlin nests. Merlin presence, rather than habitat, affects potential prey species distribution (Sodhi et al. 1990).

The small flocks occurred more frequently than large flocks at every distance, but few large flocks were found in the immediate vicinity of the Merlin nests ($X^2 = 30$, df = 3, $p < 0.001$; Table 1). Differential flock size could result from sparrows being more abundant away from the Merlin nests and I found this to be true (ANOVA, $F = 7.4$; df = 3, 192; $p < 0.05$; Figure 1). But on three occasions, I recorded 6, 6, and 7 House Sparrows at 0 m from three different Merlin nests. Out of these, 17 sparrows occurred singly and two occurred together. No such situation was observed at any other distance. This suggests that House Sparrows preferentially avoid forming large flocks when near Merlin nests.

The flock size attained by prey species may also be dependent upon detection abilities both of the prey and of the predator (Treisman 1975). Conventionally, it is thought that as flock size increases, the probability of detecting and evading a predator increases (Pulliam 1973). But paradoxically it has also been suggested that the larger flocks are more likely to be detected by a predator (Bertram 1978; Kenward 1978; Barnard 1983). Thus, by not always forming large flocks

TABLE 1. Distribution of flocks of House Sparrows at different distances from the Merlin nests. The data are presented as number of times a particular flock size was observed.

Flock size	0 m	50 m	250 m	450 m	Totals
Small (1-5 individuals)	40	31	28	33	132
Large (> 5 individuals)	1	19	24	20	64
Totals	41	50	52	53	196

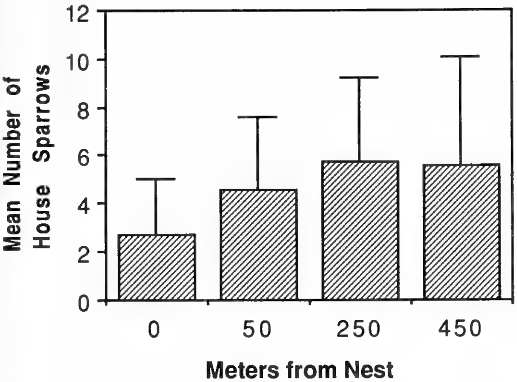

FIGURE 1. Mean number of House Sparrows at different distances from Merlin nests. Vertical lines on the top of bars represent standard deviation.

near the Merlin nests, it appears that the sparrows avoid detection. It is also possible that differential food availability at different distances may affect House Sparrow flock size (Lindstrom 1989). But if only food supply regulated the House Sparrow flock size, then smaller flocks should have occurred at a much lower frequency at 50, 250, and 450 m than at 0 m from the Merlin nests (assuming a direct correlation between the population density and food supply, *see* Krebs 1971).

Previous studies have documented that various prey species flock differently when close to Merlins. Sanderlings (*Calidris alba*) and Bohemian Waxwings (*Bombycilla garrulus*) form large flocks when pursued by Merlins (Myers 1984; Servheen 1985). In contrast, large flocks of Dunlin (*C. alpina*) break up when approached by hunting Merlins (Buchanan et al. 1988). Clearly this shows that in nature, flocking behaviour of different species differs when near a predator. Such data are essential on a prey species but rarely obtained when experimentally testing the group size and vigilance relationship.

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Ring-billed Gulls, *Larus delawarensis*, Feeding in Flight on Forest Tent Caterpillar, *Malacosoma disstria*, Cocoons

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Blomme, Chris G. 1991. Ring-billed Gulls, *Larus delawarensis*, feeding in flight on Forest Tent Caterpillar, *Malacosoma disstria*, cocoons. Canadian Field-Naturalist 105(2): 280–281.

Twelve Ring-billed Gulls were observed feeding in flight on pupae of Forest Tent Caterpillars on a Carolina Poplar. This opportunistic behavior allowed gulls to take cocoons in areas where they could not normally perch for feeding.

Key Words: Ring-billed Gulls, *Larus delawarensis*, feeding habits, Forest Tent Caterpillars, *Malacosoma disstria*, Ontario.

The Ring-billed Gull (*Larus delawarensis*) is an opportunistic feeder. Its diet reflects the seasonal availability of different food items (Haymes and Blokpoel 1978). Arthropods such as spiders, grasshoppers and other insects as well as annelids are commonly eaten (Bent 1921; Jarvis and Southern 1976). Ring-billed Gulls have been observed swallowing ground squirrels (Munro 1936) as well as the eggs of Double-crested Cormorants (*Phalacrocorax auritus*) (Bent 1921). Accounts of feeding in flight have included the capture of grasshoppers in the air (Bent 1921; Terres 1981), flying ants (Mueller 1965) and mayflies (Pettingill 1958), and Broun (1941) describes the eating of fruit while the gull hovered over cabbage palmettos.

A peak infestation year for the Forest Tent Caterpillar (*Malacosoma disstria*) occurred in portions of the Sudbury District (81° 00′ N; 46° 30′ W), Ontario, in the spring and early summer of 1988. Massive numbers of caterpillars defoliated many deciduous trees including Trembling Aspen (*Populus tremuloides*), White Birch (*Betula papyrifera*), Large-toothed Aspen (*Populus grandidentata*) and a variety of other species within the city limits. Synchronous pupation occurred from mid- to late June. The 4-cm-long cocoons are composed of silky yellow threads that encapsulate the pupae. Cocoons are spun in the topsides of leaves resulting in leaf curl as well as in bark ridges, crevices and pine needle clusters. Due to the magnitude of the infestation cocoons were observed in large numbers on trees that were not defoliated.

On 28 June 1988 (07:30) I observed Ring-billed Gulls feeding on the pupal stage of the Forest Tent Caterpillar in the city of Sudbury. A Carolina Poplar (*Populus × canadensis*) with most of its leaves was heavily infested with Tent Caterpillar cocoons. Many of these cocoons were located between twigs and in the form of leaf curls near the top portion of the 10-m tree. The tree was located along the base of a hill close to the shoreline of Ramsey Lake and its associated residential housing. Strong winds in the area (30 km/h) at the time gave rise to a strong updraft.

A group of twelve Ring-billed Gulls was observed circling the top of the Carolina Poplar, plucking, and subsequently swallowing cocoons. The gulls would glide into the wind using few wing beats. The wind was strong enough that at times gliding birds would appear motionless in midair. As an individual gull approached the tree-top, it would pluck a cocoon from the leaves or twigs. With the cocoon in its beak, the gull would slowly move upwards, still into the wind, and crush the cocoon and thus the pupa. Some resistance to swallowing was shown by the birds. The birds made numerous passes at the tree. On one occasion a gull almost perched on the light branches of the tree-top using its outstretched wings for lift as it grasped a cocoon. During the 20-minute observation and recording time a Herring Gull (*Larus argentatus*) approached the feeding Ring-billed Gulls. It was observed to glide in the same updraft within the group and attempt to rob the Ring-billed Gulls of cocoons. The Herring Gull did not attempt to feed on cocoons in the tree.

A number of factors suggest that this feeding behaviour was highly opportunistic. The large infestations of the Forest Tent Caterpillar occur only at 10- to 15-year intervals (Anderson 1960), and the pupal stage of this gregarious species lasts only one-and-a-half to two weeks (Anderson 1960) before the adult moths emerge. The positioning of many cocoons in leaf curls on light twigs should prevent feeding from a perched position by 1.5-kg Ring-billed Gulls. Proper wind conditions however, provided the opportunity for access to a food source previously unavailable. Feeding on these trees was not observed on any other occasions after this when the winds had subsided.

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Brown-headed Cowbird, *Molothrus ater*, Seen Removing a Chipping Sparrow, *Spizella passerina*, Egg

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Earley, Christopher G. 1991. Brown-headed Cowbird, *Molothrus ater*, seen removing a Chipping Sparrow, *Spizella passerina*, egg. Canadian Field-Naturalist 105(2): 281–282.

A female Brown-headed Cowbird was seen removing a Chipping Sparrow egg from the sparrow's nest. This occurred at 19:14 h and appears to represent the latest time of day at which an observation has been made of egg removal by a Brown-headed Cowbird. Time of egg removal may be linked to whether or not the host's nesting habitat is the same as the cowbird's feeding habitat.

Key Words: Brown-headed Cowbird, *Molothrus ater*, Chipping Sparrow, *Spizella passerina*, egg removal, nest parasitism.

The removal of eggs from host nests by female Brown-headed Cowbirds (*Molothrus ater*) is rarely observed. It is widely accepted that this parasitic species may remove one or more of its host's eggs, but there are few published accounts of this behaviour being seen (Nice 1937; Hann 1937, 1941; Nolan 1978). Hann (1937, 1941) made three observations of egg removal but they differ from the following account.

At 19:14 h on 12 June 1988, I noticed a Chipping Sparrow (*Spizella passerina*) taking food to a Blue Spruce (*Picea pungens*) in the southern suburbs of the city of Guelph, Ontario. Suspecting that a nest was present, I moved within 6 m of the tree to try to locate it during the bird's next visit. Shortly thereafter, the sparrow returned and perched on a telephone wire that ran alongside the nest tree, where it was joined immediately by a female Brown-headed Cowbird. The sparrow left the area without any signs of alarm. The cowbird entered the nest tree, on the opposite side from the suspected nest area, and after a short "search" it entered the nest area and was lost to my view. Less than 7 seconds later the cowbird flew from the nest area, towards me, with a Chipping Sparrow egg in her beak. She dropped the egg on the neighbouring driveway approximately 4 m from the next tree. Only then did a Chipping Sparrow begin to give alarm calls from the nest area. I found the nest a few minutes later and it contained one Chipping Sparrow egg and two Brown-headed Cowbird eggs. The Chipping Sparrow was on the nest when it was found. No further eggs were laid and all eggs hatched on 23 June 1988. Five days later the Chipping Sparrow nestling was missing. One cowbird nestling had fledged successfully by 4 July 1988 and when the nest was checked again on 7 July 1988 the other cowbird nestling was gone.

The observation is noteworthy for the time of day at which egg removal occurred. All nine of Hann's (1937, 1941) observations (three of which he saw take place) showed egg removal to have occurred in the forenoon and Mayfield (1960) states that it usually occurs before 9:00 h. My observation and one observation by Nolan (1978) and at least one by Wolf (1987) differ because they

occur after 12:00 h. My observation appears to represent the latest time of day at which an observation has been made of a Brown-headed Cowbird removing a host's egg.

Two possible explanations for the lateness of this occurrence are as follows. First, observations may be biased and reflect the time of day at which the field work was done. Field work on nesting passerines is frequently completed in the morning which clearly restricts the chance of observing afternoon removal of host's eggs by cowbirds. Second, Rothstein et al. (1984) showed that the female cowbirds spent the morning in habitats suited for nesting by many species. These same females, however, then spent the afternoons in the different and preferred feeding habitat of the cowbirds. Therefore, in such areas, removal of host's eggs should occur in the morning when the female cowbirds are present in the nesting habitats. Hann's (1937, 1941) study area was conducted in a natural forest, not in the short grass habitat used by cowbirds for feeding. This might explain why he only witnessed egg removal in the morning hours, as the female cowbirds probably left the forest for the feeding habitats in the afternoons.

In my suburban study area, cowbirds are present throughout the day and according to A. L. A. Middleton (personal communication) do not apparently move in the manner observed by Rothstein et al. (1984). This would permit female cowbirds to remove host's eggs at any time of the day. Other studies done in areas which seem suited for both nesting hosts and feeding cowbirds support this hypothesis by having records of egg removal throughout the day. Nolan (1978) observed a Prairie Warbler, *Dendroica discolor*, egg being removed by a cowbird at 5:22 h and recorded another removal between 14:15 h to 19:00 h. Wolf (1987) also recorded three Dark-eyed Junco, *Junco hyenalis*, egg removals between 10:15 h to 17:00 h. More direct observations of the egg removal process involving a variety of host species are needed to improve our understanding of this aspect of the nest parasite's behaviour.

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Isoetes tuckermanii, Tuckerman's Quillwort, an Addition to the Flora of Ontario

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Sharp, M. J., and D. M. Britton. 1991. *Isoetes tuckermanii*, Tuckerman's Quillwort, an addition to the flora of Ontario. Canadian Field-Naturalist 105(2): 283–285.

Isoetes tuckermanii is reported as an addition to the flora of Ontario. This is the first inland report of the species, the nearest known stations being in the mouth of the St. Lawrence River, Quebec.

Key Words: Tuckerman's Quillwort, *Isoetes tuckermanii*, Ontario flora, coastal plain species, new record.

Tuckerman's Quillwort, *Isoetes tuckermanii* A. Br., is reported here as an addition to the flora of Ontario, Canada. *Isoetes tuckermanii* has been considered synonymous with *I. macrospora* Dur. by some authors (e.g. Scoggan 1978, Gleason and Cronquist 1963), at least in part owing to the similarity of megaspore ornamentation; traditionally a key character for identifying *Isoetes* species. However, Kott and Britton (1983) consider them separate entities based on several differences. *Isoetes macrospora* is a decaploid (2n = 110) whereas *I. tuckermanii* is tetraploid (2n = 44). For dried material, microspore length is informative for distinguishing the two species; *Isoetes tuckermanii* microspores being smaller ($\bar{x}$ = 27 μm, range = 24-33 μm, n = 20) than *I. macrospora* ($\bar{x}$ = 42 μm, range = 32-50 μm, n = 20) (Kott and Britton 1983). Kott and Britton (1983) describe *Isoetes macrospora* as having ". . . erect, rigid and dark green leaves" while *I. tuckermanii* ". . . typically has flaccid often severely recurved and yellow green or bright green leaves". They also describe *Isoetes macrospora* as preferring deeper water. Pfeiffer (1922) describes the leaf colour as olive green.

The possibility that *I. tuckermanii* might occur in Ontario was initially suggested by a collection in 1982 at Wahwashkesh Lake, McKenzie Township, Parry Sound District (*Sharp* 617). While investigating a gravelly, sand bay for coastal plain disjuncts, a large *Isoetes* was collected that was stranded on the beach by low water levels. Although the chromosome number was clearly over 44, it was not possible to determine if this specimen was *I. macrospora* (2n = 110) or a hybrid, *I. macrospora* x *tuckermanii* (2n = 77). Based on the uncertainty of this specimen, familiarity with *I. tuckermanii* from Newfoundland, and laboratory studies at that time, it was decided that further examination of Wahwashkesh Lake was warranted.

Collection trips were made in 1985, 1986 and 1987. Cytological and scanning electron microscope (SEM) studies confirmed that *I. tuckermanii* was present in Wahwashkesh Lake. In all, seven cytological vouchers and four SEM vouchers were collected (*Britton* 10 825A, 11 238A, 11 494A and Sharp 1950). These plants were collected from water depths ranging between 0.3 m and 1.5 m. At one site, plants were also stranded above the waterline. Substrates varied from sand beaches to clay or sandy clay.

Isoetes tuckermanii was also collected in 1987 at McQuaby Lake, Nipissing Township, Parry Sound District, 50 km northeast of Wahwashkesh Lake (*Sharp* 1954). At this site *I. tuckermanii* was growing in the silty organic substrate of a sheltered bay under approximately 1 m of water. This habitat contrasts starkly with the open, sandy bays in which it mainly occurs at Wahwashkesh Lake. McQuaby Lake is in a separate drainage basin from Wahwashkesh Lake.

A subsequent herbarium search revealed an earlier (1977) collection of *I. tuckermanii*, erroneously identified as *I. macrospora*, from a third locality; the Magnetewan River, McKenzie Township, Parry Sound District (*Dickson and Brownell* 1153, in CAN). The Magnetewan River drains Wahwashkesh Lake, this site being approximately 4 km west of the Wahwashkesh Lake sites.

The distribution of *I. tuckermannii* is shown in Figure 1. The nearest previously known sites are on the St. Lawrence River in Quebec, approximately 700 km east of the Ontario locations. The main range of *I. tuckermanii* is along the eastern Atlantic seaboard from Delaware to Newfoundland, and west as far as Quebec City and Lac St. Jean. The Ontario sites are the first inland occurrence for the species in Canada.

Kott and Britton (1983) describe the habitat of *I. tuckermanii* as ". . . estuaries, lakes or ponds with changeable water levels and occasionally found in rivers or streams." They also report that it ". . . grows in water 1 m or less deep and will survive as

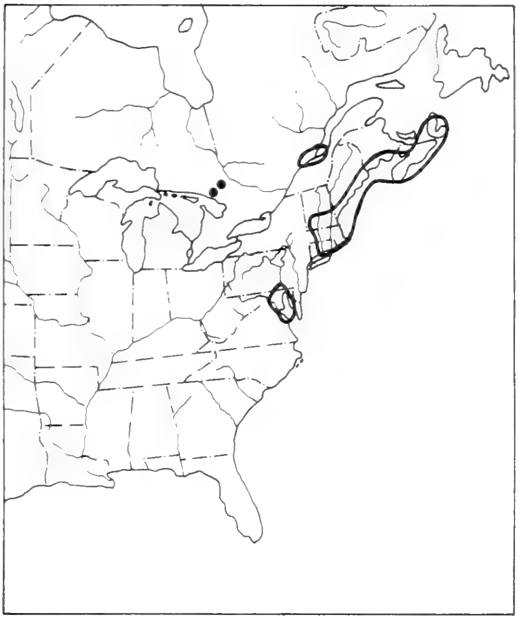

FIGURE 1. Distribution of *Isoetes tuckermanii*, in North America (adapted from Kott and Britton 1983). Solid circles are new Ontario records.

an emergent during low tide and receding water level". This characteristic is interesting as fluctuating water levels have been reported as one mechanism that enables coastal plain species to persist in Ontario (Keddy and Reznicek 1982; Sharp and Keddy 1985). *Isoetes tuckermanii* has been reported growing in sand, gravel, mud, or even peat.

Isoetes tuckermanii should be added to the growing list of rare coastal plain disjuncts which occur in the Georgian Bay area (Keddy 1981). Other coastal plain species such as Panic Grass (*Dicanthelium spretum*), Rigid Panic Grass (*Panicum rigidulum*), Waterwort (*Elatine minima*), Virginia Meadow-beauty (*Rhexia virginica*), and Yellow-eyed Grass (*Xyris difformis*), occurred at Wahwashkesh Lake, which ranked third of 49 lakes assessed for possible protection of coastal plain species (C. J. Keddy, and M. J. Sharp. 1989. Atlantic Coastal Plain Flora Conservation in Ontario. Unpublished report for the World Wildlife Fund and Natural Heritage League.) Although undoubtedly rare in Ontario, *I. tuckermanii* is likely overlooked. It should be sought in other lakes supporting coastal plain species.

Voucher Material Cited

All specimens of the authors' will eventually be deposited in OAC excepting duplicates as noted below.

hybrid:

Sharp 617, Graves Bay, Wahwashkesh Lake. Sand beach with gravelly/peat sections, many stranded on beach. 6 August 1982. This specimen died while in a growth chamber and the remains were discarded. Initial work indicated it was $2n > 44$, and, in view of its extremely robust stature, was probably a hybrid *I. macrospora* x *tuckermanii*.

Isoetes tuckermanii:

Dickson and Brownell 1153, (CAN 437264), North shore of Magnetewan River, Magnetewan Park Reserve. In shallow water. 26 July 1977.

Britton 10 825A, Opposite boat landing in front of first cottage on north shore, Wahwashkesh Lake. 1.0-1.5 m water in sand on clay, muddy water. 22 August 1985. Duplicates in DAO.

Britton 11 238A, As in 10 825A but 0.8 m of water in sandy clay. 22 August 1986.

Britton 11 494A, A large sandy bay northwest of Macy's Point. In ± 0.3 m water in sand on clay. 19 August 1987.

Sharp 1950, Just west of Macy's Point, Wahwashkesh Lake. Sandy bay in ± 0.3 m of water and stranded on beach. 24 August 1987.

Sharp 1954, In sheltered bay on east side of island, McQuaby Lake. Mucky substrate in ± 1 m of water. 25 August 1987.

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Addendum

Subsequent to the submission of this paper two additional locations for *I. tuckermanii* were discovered. Details of voucher specimens are provided below.

Brunton 10091, 5 km northeast of Dorset at east end of Otter Lake . . . at boat launch, McClintock Township, Haliburton County. in 2-5 cm deep fresh, flowing water over coarse sand . . . 24 August 1990.

Brunton and van Luit 10187, East end of Wolf Lake, Wilson Twp., Parry Sound District. . . . 20–50 cm deep fresh water in coarse sand . . . in quiet lake bay. 11 September 1990.

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A Range Extension for the Four-toed Salamander, *Hemidactylium scutatum*, in Southern Quebec

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Sharbel, Timothy F. 1991. A range extension for the Four-toed Salamander, *Hemidactylium scutatum*, in southern Quebec. Canadian Field-Naturalist 105(2): 285–286.

Two juvenile Four-toed Salamanders were caught in a peat bog on the east side of Lake Memphremagog, Stanstead County, Quebec (45°02′ N, 72°11′ E) in September 1989. These extend the known range approximately 100 km east of previous Quebec sightings and 120 km north of New England sightings. This species may be restricted to a patchy distribution in suitable habitats throughout southern Quebec.

Key Words: Four-toed Salamander, *Hemidactylium scutatum*, sphagnum bog, Quebec.

The Four-toed Salamander *Hemidactylium scutatum*, is an uncommonly recorded species in Quebec (Bider and Matte 1990; Joel Bonin. 1989. *Inventaire de la Faune Herpétologique de la Réserve Écologique du Pin-Rigide*. Ministere de l'Environnement du Quebec. 40 pages; Gordon 1979; Denman 1961; Gorham 1955). Two are reported here from Stanstead County, Quebec. These extend the known range approximately 100 km east of previous Quebec sightings (11 km east of Covey Hill, Huntington County, Quebec, 45°01′ N, 73°38′ W; Gordon 1979) and 120 km north of New England sightings (Lake George, Warren County, New York, 43°30′ N, 73°40′ W; Bishop 1941).

I collected them at Marlington Bog, 30 km south of Magog, on the east side of Lake Memphremagog (45°02′ N, 72°11′ E). Marlington Bog is a typical peat bog (*Sphagnum* sp.) covering an area of approximately 12 hectares. The surrounding forest is dominated by maple (*Acer saccharinum, A. rubrum*), Black Spruce (*Picea mariana*), Eastern Hemlock (*Tsuga canadensis*), and Tamarack (*Larix laricina*) (T. F. Sharbel. 1989. *The herpetofauna of Marlington Bog, Quebec*. Report to the Quebec Ministry of Environment and the Nature Conservancy of Canada).

Pitfall traps in association with drift fences were laid out in the center of the bog and along its southern perimeter from 1 September until 7 October 1989. A juvenile *H. scutatum* (SVL [snout-vent length] = 24.41 mm) was caught on 23 September as it was crawling through leaf litter near the perimeter trap. This individual was photographed and has been deposited at the National Museum of Natural Sciences in Ottawa (NMC 32481). A second juvenile (SVL = 21.62 mm) was caught on 30 September in one of the perimeter pitfalls and was released after identification and measurement.

This range extension may indicate that *H. scutatum* has a patchy distribution throughout southern Quebec. There are records of this species from Ontario, southwestern Quebec, New Brunswick, Nova Scotia, and northern New England (Woodley and Rosen 1988; Cook 1984; Gilhen 1984; Bishop 1941). The absence of data for this species in southern Quebec may also reflect the difficulty of performing adequate surveys for it and the irregular distribution of suitable habitats (mainly peat bogs). The usefulness of pitfall traps to survey for this species is apparent, as many hours of traditional manual searching yielded no specimens.

Acknowledgments

I thank J. Bonin for his help in setting up the traps, and D. M. Green and D. A. Good for their comments on the manuscript.

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Notes on Reproduction of Old (≥ 9 years) Free-ranging White-tailed Deer, *Odocoileus virginianus*, in the Adirondacks, New York

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Masters, R. D., and N. E. Mathews. 1991. Notes on reproduction of old (≥ 9 years) free-ranging White-tailed Deer, *Odocoileus virginianus*, in the Adirondacks, New York. Canadian Field-Naturalist 105(2): 286-287.

Reproductive records of older aged deer (9-16 years) are reported for the central Adirondack Mountains in New York (4 870 000 m North and 564 000 m East). This is the first report of reproduction in known-aged, older, free-ranging female deer.

Key Words: White-tailed Deer, *Odocoileus virginianus*, reproduction, longevity.

While longevity of free-ranging female White-tailed Deer (*Odocoileus virginianus*) has previously been documented (Ozoga 1969), little information is available on productivity for older-aged (≥ 9 yr) individuals especially in northern climates. In northern Maine, Palmer (1951) reported that a free-ranging, supplementally fed, doe produced two and three fawns every year, except one, from age five to 13 yr. Gordon et al. (1975) and Tullar (1983) reported that a 19 to 23 yr old doe (based on tooth-sectioning and cemental annuli) was harvested in southern New York and carried on 80-day-old fetus. McCullough (1979) reported a 12-yr-old carrying a single embryo in southern Michigan. Although these reports suggest that female deer are physiologically capable of producing fawns throughout their lives, each was based on an observation of a single individual. We report single and repeated observations of six, free-ranging does, known ages nine to 16 yr, which either conceived or produced fawns in the central Adirondack region in New York.

The study was conducted on the Huntington Wildlife Forest (HWF), located five km west of Newcomb, New York (4 870 000 m North and 564 000 m East). The terrain is mountainous and the habitat is characterized by continuous forest cover comprised of 70% northern hardwoods and 30% conifers or mixed hardwoods and conifers (Mathews 1989). Winters are severe, averaging 330 cm of snowfall. Extreme climatic conditions in combination with poor soil productivity (Cheatum and Severinghaus 1950) have created relatively poor range conditions for deer.

HWF has been virtually unhunted for the past 80 yr with the exception of limited either-sex deer harvest on its northern portion during 1966-1970

and 1978-1984. The lack of continued harvest pressure has lead to an older age-structure in the population (Underwood 1986).

Since 1964, White-tailed Deer have been captured, marked, and radio-collared on the 6000 ha Huntington Wildlife Forest. Reproductive characteristics and age (juvenile or adult) were determined at the age of capture. Subsequent observations and locations of marked females with fawns were recorded.

Of the 500 individuals marked and radio-controlled, six older females ($\geq$ 9 yr) were known to have conceived or produced fawns (Table 1). Minimum ages of all but one of these females were known, based on live-capture records. Only one individual was observed to be barren at age 13 but she produced fawns at both 14 and 15 yrs.

In most populations of free-ranging deer, the proportion of females living to older ages is relatively small and their reproductive contributions are rarely considered significant. In addition, it is generally believed that older females either cease to reproduce or produce fewer fawns because of purported reproductive senility. The observations presented here contradict this. Additional information on ovulation rates, however, is required to more fully evaluate physiological reproductive senility. Recent studies also indicate that older females are more successful at raising fawns because of their experience (Ozoga and Verme 1986). If older females continue to produce fawns at a rate similar to younger females, and the age structure of the population is relatively old, then the contributions of these older females may have a significant impact on population demographics. Such older-age structured populations can occur on refuges or preserves where hunting is proscribed and may present managers with special considerations.

TABLE 1. Reproductive records of older-aged ($\geq$ 9 yr) female White-tailed Deer on Huntington Wildlife Forest, Newcomb, New York, 1966-1989.

Female Number	Observation
1	Observed with two fawns at a minimum known age of 9 yr.
	Observed with one fawn at a minimum known age of 10 yr.
2	Recovered dead in late spring carrying 2 fetuses; minimum known age of 10 yr.
3	Observed with two fawns at known age of 11.
	Observed with two fawns at known age of 12.
	Barren at capture at known age of 13.
	Pregnant at capture during early summer at known age of 15.
4	Observed with one fawn at minimum age of 11 yr.
5	Lactating during mid-summer at estimated age of 11 yr.
	Pregnant at capture during early-summer at estimated age 12 yr.
6	Pregnant at capture during early-summer at a known minimum age of 15 yr.

Acknowledgments

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Introduction and Dispersal of the Pacific Treefrog, *Hyla regilla*, on the Queen Charlotte Islands, British Columbia

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Reimchen, T. E. 1991. Introduction and dispersal of the Pacific Treefrog, *Hyla regilla*, on the Queen Charlotte Islands, British Columbia. Canadian Field-Naturalist 105(2): 288-290.

In about 1962, Pacific Treefrogs, *Hyla regilla*, from near Comox Lake, Vancouver Island, were transplanted to the Queen Charlotte Islands where the only native amphibian is the Western Toad *Bufo boreas*. The initial population of about six adults increased in numbers and expanded its range into a diversity of habitats. Secondary transplants have been made by local residents to other regions in the archipelago. Each of these has led to new dispersal fronts and currently the treefrog has a range of ca. 2600 km² (26% of the total area of the islands). Dispersal rate was estimated at about 2 km/y, but has been aided by secondary introductions.

Key Words: Pacific Treefrog, *Hyla regilla*, Western Toad, *Bufo boreas*, Queen Charlotte Islands, introduction, dispersal rate.

The Queen Charlotte Islands, British Columbia, have an impoverished native vertebrate fauna of which the amphibians are represented by a single species, the Western Toad, *Bufo boreas* (Foster 1965). In the 1930s and in the early 1960s, the Pacific Treefrog, *Hyla regilla*, common in southern regions of British Columbia (Carl 1966; Green and Campbell 1984), was introduced to the Queen Charlotte Islands and has now become widespread. Here, I provide a brief description of these introductions and the subsequent dispersal across the archipelago.

Since 1967, I have maintained site records (visual or acoustical) of treefrogs during biological surveys of lakes in the Queen Charlotte Islands. Historical information was collated from discussions with local residents. General physiography of the Queen Charlotte Islands are described in Calder and Taylor (1968).

Ranges of the treefrog on the Queen Charlotte Islands in 1970, 1979 and 1988 are summarized in Figure 1. The first introduction of treefrogs to the Queen Charlotte Islands allegedly occurred about 1933 when several adults, collected from Vancouver, British Columbia, were released on the north-eastern tip of Moresby Island (B. Mathers, personal communication). No treefrogs were observed in subsequent years and it is presumed that this introduction was unsuccessful. In summer of 1961 or 1962, D. Rennie (personal communication), collected approximately six adult treefrogs from near Como Lake, Vancouver Island, and transplanted these to his home at Port Clements, Graham Island. These individuals established a breeding population and within several years a chorus of adult treefrogs was common in roadside ditches within the town.

By 1970, treefrogs were heard in ponds up to 7 km north of the town (D. Rennie, personal communication; S. Simpson, personal communication) but were absent further north (Figure 1a). By 1978, they had reached 25 km north of Port Clements but were still limited to a corridor adjacent to Masset Inlet since I did not observe individuals further inland during extensive ground surveys in 1979 (Figure 1b). By 1982, the corridor was approximately 6 km in width indicating gradual easterly dispersal into the *Sphagnum* lowlands. Much of the dispersal was likely terrestrial although the numerous small ponds would also allow aquatic dispersal of adults and larvae. Over this corridor, streams tend to flow in a westerly direction and would not have assisted northern dispersal. I did observe treefrogs at a single site 15 km further inland than the main dispersal front in 1979. This disjunct locality was close to one of the north-flowing rivers which dissect the central region of the lowlands, suggestive of downstream transport. In 1986, eastern dispersal from Masset Inlet extended 20 km across the lowlands.

Dispersal into the heavily forested habitats south of Port Clements is not as well documented; but by 1970 treefrogs were present up to 8 km from the town (D. Rennie, personal communication). In 1976, I observed them at an isolated lake 25 km to the southwest of Port Clements.

Secondary transplants of treefrogs have occurred in various localities on the islands, principally towns or small settlements (Figure 1c); in 1965, tadpoles from ditches in Port Clements were transplanted to a roadside pond 6 km southeast and to Mayer Lake, 10 km south-east of the town (D. Rennie, personal communication) where by 1967, adults were abundant (personal observation). The secondary introduction to Mayer Lake may comprise the source population for the major eastern and southern dispersal fronts on Graham Island; by 1970, treefrogs were

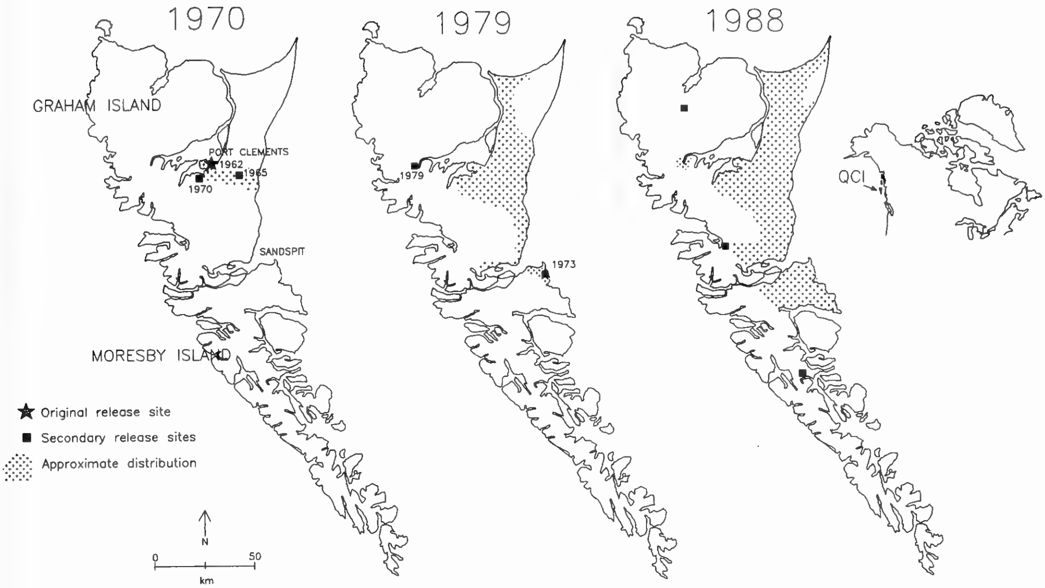

FIGURE 1. Geographical distribution of the Pacific Treefrog, *Hyla regilla*, on the Queen Charlotte Islands, British Columbia. Place names restricted to those used in the text.

observed up to 10 km south of Mayer Lake (L. Rennie, personal communication) and by 1978, occurred an additional 30 km to the south. By 1986, I observed them in all of the major watersheds of central and mid-eastern Graham Island. Dispersal from Mayer Lake also occurred to the east. In 1986, individuals were observed in a narrow corridor up the eastern side of Graham Island, probably as a consequence of access to north-flowing drainage. Presumably, this secondary northerly dispersal from Mayer Lake will merge with the easterly front that dispersed north and west from Port Clements (see Figure 1c).

Between 1975 and 1977, treefrogs were transplanted from roadside ponds in the southeastern region of Graham Island to Queen Charlotte City at the southern edge of Graham Island (K. Moore, personal communication) and by 1986, were heard in roadside ponds up to 30 km northwest. In 1980 or 1981, treefrogs were transplanted (probably from the Port Clements area) to a logging camp near the south-western head of Masset Inlet on Graham Island (M. Dunderdale, personal communication). This population expanded and recently (May 1989) individuals have been observed in sub-alpine ponds 6 km to the west of release site (C. Williamson, personal communication), representing the first sighting of treefrogs on the western slopes of the archipelago.

In 1973, five adult treefrogs collected from Port Clements were transplanted to the north-eastern corner of Moresby Island near Sandspit (N. Blount, personal communication). These individuals formed a successful breeding population and have greatly expanded their range, occurring over a 525 km ^{2} region by 1988. Additional transplants appear to have occurred to the central Moresby Region since in 1982, an adult treefrog was observed in a mountain valley 60 km south of Sandspit (K. Moore, personal communication).

Current distribution and summary of suspected dispersal routes are shown in Figure 1c. Total area currently occupied by the treefrogs is about 2600 km^2 comprising 26% of the surface area. The numerous secondary transplants during the last two decades, of which only some are known, confound any rigorous efforts to examine the dispersal rate. However, compilation of the records where presence/absence information is available for a series of years and where secondary introductions can be excluded yields an average dispersal rate of 1.9 km/y, range 1.1 - 2.5 (Table 1). These data are derived principally from the low elevation terrain (< 100 m) in eastern Graham Island which is characterized by thousands of ponds (Douglas and Reimchen 1988) and where, presumably, the habitat is conducive for rapid dispersal and colonization. Moresby Island is mountainous throughout its length with deeply indented coastlines and, as such, dispersal will be much slower. General dispersal rates of toads and frogs are quite variable. American Toad (*Bufo americanus*) spread at an average rate of ca.

TABLE 1. Estimated dispersal rate of Pacific Treefrog on the Queen Charlotte Islands. Localities where secondary transplants are suspected are excluded.

Source-Date	Locality[1]-Date	Distance (km)	Dispersal (km/y)
Port Clements-1963	L#32: 1970	8	1.1
Port Clements-1963	Sheila Lake: 1976	25	1.9
Port Clements-1963	Drizzle Lake: 1977	30	2.1
Port Clements-1963	L#1041: 1979	40	2.5[2]
Port Clements-1963	L#115: 1986	30	1.3[2]
Port Clements-1963	L#1800: 1986	25	1.9
Mayer Lake-1966	Tlell: 1970	10	2.5
			$\bar{x}$ = 1.9

[1]Locations (#) designated from District Lot Number.
[2]Adjacent stream may have accentuated downstream dispersal.

0.3 km/yr (maximum 1 km/yr) following their introduction to Newfoundland (Maunder 1983) while *Rana berlandieri* spread via water courses at a rate of 6-16 km/yr across Arizona (Platz et al. 1990).

The introduction of the treefrog on the Queen Charlotte Islands parallels the frequent and global pattern of exotic introductions into archipelagoes (Simberloff 1988). The ecological effect on the native biota of this introduction will be difficult to ascertain since a diversity of confounding factors are operating. This is only one of twelve vertebrate species to have been introduced to the archipelago within the last 80 years, some of which have greatly influenced the native species (Reimchen, Douglas and Moore, unpublished data). The expanding treefrog populations could, through trophic interactions, or competition for breeding habitat, adversely affect the native toad, some populations of which have already been depleted from predation by the recently introduced Racoon (*Procyon lotor*) (personal observation). Finally, one of the more fundamental changes to the natural habitat of the Queen Charlotte Islands resulting from this introduction is the diurnal and nocturnal vocal chorus which now dominates the bioacoustical environment in spring. Whether this interferes with communication of other taxa is unknown. Substantial opportunities for ecological, genetical and evolutionary investigations are possible as this species continues to expand its range and colonize a diversity of habitats in the archipelago.

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Snowshoe Hare, *Lepus americanus*, Use of Forest Successional Stages and Population Changes During 1985-1989 in North-central Washington

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Koehler, Gary M. 1991. Snowshoe Hare, *Lepus americanus*, use of forest successional stages and population changes during 1985-1989 in north-central Washington. Canadian Field-Naturalist 105(2): 291–293.

Snowshoe Hare (*Lepus americanus*) pellet counts along 24 permanent transects in north-central Washington showed hare numbers to be greatest in $\leq$ 25-year-old successional forests. Observations of numbers of hare tracks during winters indicated that hare numbers did not peak or crash during 1985-1989. Compared to more northern latitudes where numbers of hares change 6-100-fold during 2-5 year intervals, pellet counts showed hare numbers on the study area decreased 1.5-fold from 1986 to 1989. Observations that hare numbers either do not fluctuate or the cyclic changes in hare numbers are greatly dampened within the study area supports the hypothesis that Snowshoe Hare populations do not radically fluctuate at southern latitudes.

Key Words: Snowshoe Hares, *Lepus americanus*, population cycles, successional forest stages, Washington.

While Snowshoe Hare (*Lepus americanus*) numbers are known to cycle every 8-11 years at northern latitudes (Elton and Nicholson 1942; Keith and Windberg 1978; Keith 1981), they do not show such radical fluctuations at the southern periphery of their range (Chitty 1950; Dolbeer and Clark 1975; Wolff 1980, 1981; Keith 1981). Understanding the habitat requirements and dynamics of regional Snowshoe Hare populations has important ecological and management implications. To assess Snowshoe Hare use of forest successional stages and possible changes in hare numbers in north-central Washington I compared counts of Snowshoe Hare fecal pellets among four successional forest stages between September 1986 and September 1989 and compared observations of relative numbers of hare tracks present each winter from 1985 through 1989.

Study Areas and Methods

The study area was located in north-central Washington (48° 50′N, 119° 52′W) between elevation 1536-1952 m (Koehler 1990). Wild fires and timber harvesting have produced a mosaic of successional forest stages, including mature forests where Engelmann Spruce (*Picea engelmannii*) and Subalpine Fir (*Abies lasiocarpa*) predominate and younger-aged forest where Lodgepole Pine (*Pinus contorta*) is the dominant overstory tree. Because numbers of Snowshoe Hare fecal pellets are reliable estimators of Snowshoe Hare numbers (Litvaitis et al. 1985a; Krebs et al. 1986), I compared counts of pellets among successional forest stages and between years 1986 and 1989 to determine use of habitats and to assess changes in numbers over time. Fecal pellets were counted along 24 permanent transects within the four most prevalent successional forest states (six transects/successional stage). Based on species and average age (determined from increment boring) of dominant overstory trees the four successional stages included: (1) forests with a Lodgepole Pine overstory ≤ 25 years old, (2) Lodgepole Pine forests ~ 46 years old, (3) Lodgepole Pine forests > 80 years old, and (4) Engelmann Spruce/Subalpine Fir forests > 100 years old. Transects were 100 m long and spaced at ≥ 325 m intervals along and perpendicular to the road that bisected the study area. This spacing was selected to ensure independence of counts between transects and assumed that home range sizes for hares were < 8.8 ha (Wolff 1980). Ten 1-m radius circular plots were positioned at 10 m intervals along each 100-m transect. Pellets within each circular plot were counted before leaf fall during September 1986 and September 1989. Pellets were counted on the same plots during both years and it was assumed that pellet decomposition rates were similar for both periods. Pellets were summed for each transect and the mean number of pellets among the four successional stages were compared within years using ANOVA and Tukey's method of multiple comparisons (Zar 1984). Counts between 1986 and 1989 were compared using paired *t*-tests. I also made observations of Snowshoe Hare tracks each winter from 1985-1989 to determine whether hares were rare, common, or abundant.

Results and Discussion

Pellet counts indicated that Snowshoe Hare numbers were up to 16.0-times more abundant in the $\leq$ 25-year-old Lodgepole Pine forests than in the older-aged successional stages during 1986

TABLE 1. Mean number of Snowshoe Hare pellets m² within successional forest stages in north-central Washington during 1986 and 1989 (n = 6 transects successional stage). Counts followed by a common letter were not significantly different ($P > 0.05$, Tukey multiple comparisons tests).

Successional Forest Stage	1986 Mean ± SD	1989 Mean ± SD
Lodgepole Pine ≤ 25 yrs	15.8 ± 13.3A	14.9 ± 6.1 A
Lodgepole Pine ~ 46 yrs	12.7 ± 7.1 A B	5.2 ± 2.5 B
Lodgepole Pine > 80 yrs	5.9 ± 5.1 A B	2.8 ± 1.8 B
Engelmann Spruce/Subalpine Fir > 100 yrs	1.0 ± 0.7 B	1.4 ± 1.7 B

(F = 4.3, $P = 0.02$) and 1989 (F = 18.1, $P < 0.001$). Koehler (1990) observed Snowshoe Hares to be more abundant in these ≤ 25-year-old Lodgepole Pine forests where density of tree and shrub stems averaged 16 320 stems/ha than in the older-aged successional forests where stem density averaged ≤ 4800 stems/ha. Densely stocked stands are important for the forage, escape, and thermal cover they offer Snowshoe Hares (Adams 1959; Wolff 1980; Wolfe et al. 1982; Pietz and Tester 1983; Litvaitis et al. 1985b; Fuller and Heisey 1986).

Average counts of Snowshoe Hare pellets in 1986 [$\bar{x} \pm SD = 8.9 \pm 9.5$ pellets/m²] were 1.5 times greater than in 1989 (6.0 ± 6.3 pellets/m², differences between years were significant t = 2.2, $P = 0.04$), suggesting that Snowshoe Hare numbers declined during this period. However, comparisons of pellet counts within each successional stage between years (Table 1) indicated only counts in the approximately 46-year-old Lodgepole Pine forests were significantly different (t = 3.0, $P = 0.03$). Differences between years within ≤ 25-year-old Lodgepole Pine, > 80-year-old Lodgepole Pine, and Engelmann Spruce/Subalpine Fir successional stages were not significant ($P > 0.05$). The 1.5-fold decrease in pellet counts within the study area and 2.5-fold decrease within ~ 46-year-old Lodgepole Pine successional stage during three years compares to a 6-100-fold change in Snowshoe Hare numbers during 2-5 year intervals at more northern latitudes (Brand and Keith 1979; Parker et al. 1983; Ward and Krebs 1985).

The slight (1.5-fold) change documented from pellet counts during this study and observations of Snowshoe Hare tracks each winter indicating no peak or crash in hare numbers from 1985-1989 suggests that Snowshoe Hare populations in the north-central Washington study area remained relatively stable. Although caution is required when extrapolating these findings to longer time periods or to larger areas (Wiens et al. 1986) these data indicate that although annual variations in numbers of hares may occur, the typical "cycle" may either be lacking or dramatically dampened within the study area. Surveys conducted during the 1930-1940s indicate Snowshoe Hare numbers may not show the regional fluctuations in the western United States (Chitty and Elton 1937) or in southern British Columbia (Chitty 1950). Similar correlations between latitude and population dynamics have been documented in Fennoscandia and Scandinavia for small rodents (Hansson and Henttonen 1985; Linden 1988). The relatively stable Snowshoe Hare populations at southern latitudes may, in part, result from a lack of large sized areas of optimal habitat (Chitty and Elton 1937; Dolbeer and Clark 1975; Keith 1981; Wolff 1981). Indeed, the young-aged Lodgepole Pine successional stages where Snowshoe Hare numbers were most abundant existed as small isolated pockets, fragmented by a diversity of exposure, slopes, soils, elevations, and older-aged forest cover types. Fire suppression in the past five decades has affected the patterns of forest succession in the study area too, reducing the amount of optimal habitats for hares and undoubtedly affecting the dynamics of hare populations.

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News and Comment

EARTHWATCH: Research Grants Available

Earthwatch, a private non-profit organization that promotes significant scholarship by offering capital, labor, and greater visibility to the scientific community, will award more than 140 grants in 1992. Field grant's range from $10,000 to $100,000, with the average grant about $20,000. Funds are contributed by nonspecialist volunteers who participate in the field research. Preliminary proposals may be made by telephone or by a detailed letter; upon favorable review, full proposals will be invited for submittal 12 months before the starting date of the project.

Since its founding in 1971, the organization has mobilized 1,131 field seasons of 795 projects in 87 countries and 36 states. To date, over 28,000 EarthCorps volunteers have contributed over 17 million dollars and 2,715,264 hours to the search for solutions to important problems around the world. The mission of EARTHWATCH is to improve human understanding of the planet, the diversity of its inhabitants, and the processes which affect the quality of life on earth. We are a coalition of citizens and scientists working to sustain the world's environment, monitor global change, conserve endangered habitats and species, explore the vast heritage of our peoples, and foster world health and international cooperation. In 1991 EARTHWATCH will sponsor 135 projects divided into two-to-three week long teams to enable members of the public to join. Expeditions by discipline include 7 projects in Rain Forest Conservation and Ecology, 36 projects in Art and Archaeology, 20 projects in Geosciences, 47 in Life Sciences, 21 in Marine Studies, and 4 in the Social Sciences.

For further information contact: Dee Robbins, Program Director, The center for Field Research, 680 Mt. Auburn Street, P. O Box 403, Watertown, MA 02172, telephone (617) 926-8200.

Editor's Report for Volume 104 (1990)

A total of 87 manuscripts were submitted to *The Canadian Field-Naturalist* in 1990. The publication delays which have plagued us were not completely caught up during 1990; 104(1) was mailed 22 September and 104(2) 22 December 1989; but 104(3) and 104(4) were in galley by the end of the year and appeared on 20 February and 25 April 1991.

Volume 104 totalled 642 pages, the largest single issue (2) was 180 pages. The number of research and observation contributions are summarized in Table 1, the totals for Book Reviews and New Titles in Table 2, and the distribution of published pages in Table 3. COSEWIC Status Reports on fish and marine mammals were again edited by Bob Campbell and appeared in 104(1) with page, table, and figure costs, as well as reprint charges, funded by the Department of Fisheries and Oceans. The series on The Peregrine Falcon in the 1980s in 104(2) was coordinated by David Peakall, and the Canadian Wildlife Service, Environment Canada, funded page charges.

P. J. (Mickey) Narraway acknowledged manuscripts and reviews and compiled a computer listing of all reviewers and their addresses that was of fundamental importance in streamlining the operations of the journal in 1990 and made a major contribution to the clearing the backlog. L'Arrivée proof-read the galleys for 104(1) before resigning this task after seven years, in order to devote more time to other activities including his growing involvement as a toast-master; Joyce Cook for 104(2) and Wanda Cook for 104(3) and 104(4), completed the year.

Bill Cody had a very hectic year as business manager including processing all reprint orders and innumerable trips to the printer as we cleared up the back issues from the previous volume and not only had all for the current year set, but much of the material in the printers hands for the first two issues of 1991. Lois Cody handled the innumerable inquiries on the lateness of the journal, a task we expect to be lightened in 1991. M.O.M. Printers, Ottawa, continued to set and print the journal; Emile Holst and Eddie Finnigan maintained grace under the pressure as we asked them to set nearly two volumes in one year. E. Wilson Eedy forged ahead with the vital task of book review editor and his report will appear separately. Harvey Beck compiled the Index with his usual uncanny speed and accuracy. George La Roi coordinated the Biological Flora of Canada, and, although no new contributions appeared in 1990, the series still active.

In the past year we have had several changes in our panel of associate editors after nearly a decade of stability, losing some long-time supporters to increased work-loads in their other commitments,

TABLE 1. Number of articles and notes published in *The Canadian Field-Naturalist* Volume 104 (1989) by major field of study.

Subject	Articles	Notes	Total
Mammals	17	15	32
Birds	24	5	29
Amphibians and reptiles	2	1	3
Fish	15	0	15
Invertebrates	1	2	3
Plants	4	2	6
Other*	1	0	1
	64	25	88

*Fish and Marine Mammal COSEWIC subcommittee report. Reports on individual species (7 mammals and 14 fish) are included in group totals.

TABLE 2. Number of reviews and new titles published in Book Review section of Volume 104 by topic.

	Reviews	New Titles
Zoology	58	130
Botany	14	63
Environment	16	92
Miscellaneous	7	14
Young Naturalists	7	63

and welcoming some new editorial opinion. Early in 1990, E. L. Bousfield (invertebrates) stepped down and Diana Laubitz replaced him, and D. E. McAllister (fish), relinquished his role to Brian W. Coad. C. G. Van Zyll de Jong (mammals) and C. J. Jonkel (predator-prey relationships) retired from their associate duties at the end of the calendar year. A. J. Erskine (birds) requested that his load be lightened through this year and much of next because of his commitment to the completion of the Maritime Bird Atlas in 1991 and W. Bruce McGillivray and W. Earl Godfrey assumed much his former review load. Both have long served as reviewers, and Earl was previously an Associate Editor from 1946 to 1975. Our other three long-time associates, W. O. Pruitt (mammals), C. D. Bird (botany) and S. M. Smith (insects) continued their active roles. A new addition in 1991 will be R. R. Campbell (fish and marine mammals) who has contributed already by editing the COSEWIC status reports since 1984.

The associate editors were assisted by the following 100 additional reviewers who commented on one or more manuscripts though the calendar year: R. C. Anderson, G. W. Argus, T. W. Arnold, W. K. Ballard, V. G. Barnes, Jr., D. Belk, J. R. Bider, J. S. Bleakney, J. P. Bogart, H. Boyd, R. O. Brinkhurst, D. Britton, R. J. Brooks, D. L. Brunton, S. Buskirk, C. A. Campbell, R. R. Campbell, P. M. Catling, L. N. Carbyn, Fu-Shiang Chia, K. A. Coates, W. J. Cody, J. Cayoutte, R. Chengalath, P. R. Croskery, E. J. Crossman, A. Cyr, P. Dansereau, S. Darbyshire, R. W. Davies, F. Dean, J. R. Duncan, C. H. Ernst, W. G. Evans, R. Fagen, J. Ferron, F. L. Filion, J. Gilhen, W. M. Giviland, D. M. Green, R. H. Green, E. Haber, C. Hand, F. H. Harrington, R. R. Ireland, R. D. James, C. S. Johnson, L. B. Keith, L. Kilham, G. H. La Roi, R. N. Lea, J. Lien, C. C. Lindsey, J. R. Longcore, H. G. Lumsden, R. D. MacCulloch, G. L. Mackie, J. Madill, A. Martel, L. D. Mech, J. S. Millar, S. Miller, T. Mosquin, W. T. Munro, R. W. Nero, D. Nagorsen, M. E. Obbard, M. J. Oldham, R. B. Owen, J. Packer, G. R. Parker, K. Patalas, A. Peden, R. O. Peterson, M. K. Phillips, J. B. Phipps, J. Picman, J. Prescott, M. Raine, T. E. Reimchen, R. J. Robertson, L. L. Rogers, J. S. Rowe, F. W. Schueler, W. B. Scott, D. W. Soprovich, H. C. Smith, J. N. M. Smith, R. Stardom, M. M. Stewart, K. W. Stewart, C. W. Taylor, J. R. Tester, J. B. Theberge, M. L. H. Thomas, R. D. Titman, W. F. Weller, R. E. Wrigley, P. M. Youngman, S. C. Zoltai.

My thanks are again due President Ron Harrison of the Ottawa Field-Naturalists' Club, to

TABLE 3. Number of pages published in *The Canadian Field-Naturalist* Volume 104 (1990) by section (number of manuscripts in parenthesis).

Issue number:	— 1 —	— 2 —	— 3 —	— 4 —	Total
Articles	145 (22)	126 (13)	126 (18)	64 (11)	461 (64)
Notes	0 (0)	15 (7)	13 (8)	22 (10)	50 (00)
News and Comment items	0 (0)	4 (6)	9 (5)	3 (2)	16 (13)
Book Reviews*	21 (22)	34 (34)	24 (22)	18 (24)	97 (102)
Index	—	—	—	17 (1)	17 (1)
Advice to Contributors	0 (0)	1 (1)	0 (0)	0 (0)	1 (1)
Total pages:	166	180	172	124	642

*Total pages include both reviews and new titles but parenthesis figure includes only number of reviews.

the Club Council, and to Chairman Ron Bedford and the Publications Committee of OFNC giving me consistent support through the year. The National Museum of Natural Science (which, on 1 July 1990, became the Canadian Museum of Nature) continued to provide space and support to the journal in a year of extended difficulties with building conditions and transition. Joyce provided steadfast encouragement throughout, and, this year, part of the proofreading as noted above.

FRANCIS R. COOK
Editor

Book Reviews

ZOOLOGY

A Field Guide to Hawks, North America

By William S. Clark and Brian K. Wheeler. 1987. Houghton Mifflin (Canadian distributor: Thomas Allen, Markham, Ontario). 198 pp., illus.

The Peterson field guide system is probably the best known and popular method of identification of all things natural. To date there have been 36 field guides published which use this system, all edited by Roger Tory Peterson, and *A Field Guide to Hawks, North America* is No. 35 in the series. Seven of the titles relate to birds, with most of these written by Roger Tory Peterson himself. *A Field Guide to the Hawks, North America* is, however, the first in the series devoted exclusively to one group of birds. To quote the authors: "this field guide is designed to present the latest in tried and proven field marks ... and behavioral characteristics by which the 33 regular and six accidental N. American diurnal raptors may accurately be identified".

A Field Guide to Hawks comes as a nice well-bound pocket size guide with a selection of black-and-white photographs, and plates of flying and perched hawks and vultures by Brian Wheeler. The coverage for each species includes a detailed description, field marks, plumages, similar species, flight behaviour, voice, status and distribution, range maps, fine points, unusual plumages, subspecies, etymology (origins of the common and scientific names), and measurements. William Clark brings to this text his extensive field experience, which includes work at Cape May Observatory, the Raptor Information Centre at the National Wildlife Federation in Washington, and at the Israel Raptor Information Centre at Elat, Israel. The excellent text is light and to the point and the critical field marks are italicized for easy reference. The description, similar species and status and distribution are repeated opposite each plate for even easier reference.

The range maps are included with the description, and are clear and fully half a page in size. Accuracy of range maps is almost always brought into question, but in this case I could not spot any obvious errors. The plates, as with other Peterson guides, are collated at the end of the book together with the black and white photographs. Frankly, I found the plates a little disappointing in both colour and substance. While they look pretty, they lack the pleasing natural aspect and quality of the original Peterson plates. The body shape of many of the hawks, both perched and flying, appear to me at least, odd and stiff. In particular, many of the flying birds look unnaturally short-winged and stunted. Plate 5 (accipitors) and plates 19/20 (eagles) are particularly poor. For the observer, the shape and "feel" of the hawk is particularly important when identifying birds at a distance. The field marks are carefully enhanced, but occasionally the colour is lacking, being either too dense or too light, or the wrong shade. Also, in a few cases, the printing has resulted in very dark plates. The silhouettes presented on pages 6 to 8 are also questionable when it comes to the shape of the Osprey, harriers, and eagles.

The black-and-white photographs of flying birds no doubt were very difficult to compile. Obtaining good in-flight shots is notoriously difficult. Actually, many of the shots are excellent but are very dark when reproduced. Others are just too much out of focus to be of real value. I feel it would have been a distinct advantage to have reproduced as many as possible in colour; this would have helped in the interpretation of the plates.

The birdwatcher and casual observer to which this book is designed to appeal will find the book wanting from the point of view of the plates but still worth having along when a raptor pops into view, if only for the fine points of identification. Rarely does a raptor sit still long enough at close range in perfect light while it is identified! A fleeting or distant look at a rapidly moving hawk is more likely, and this book will help identify at least some of them.

The Editor's note which precedes the text was written by Roger Tory Peterson. In it, he identifies the need for a field guide designed to discuss various plumages, regional variations and colour morphs and ". . . the effect of air currents and thermals on the silhouette and wing action when the bird was in flight". I take issue that the book addresses the latter, while it does succeed in the former.

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The North American Porcupine

By Uldis Roze. 1989. Smithsonian Institution Press, Washington. x + 261 pp., illus. Cloth U.S. $29.95; paper U.S. $19.95.

Porcupines are often regarded more as a curiosity than a source of inspiration. Biologist Uldis Roze has a different view. In this excellent contribution to the Smithsonian Nature Book series, Roze shows the true colours of an unabashed porcupine fan. And his interest is contagious. With fine writing and hard data, Roze brings the natural history of these low key and seemingly simple creatures to vivid life.

Dr. Roze has studied porcupines in the Catskill Mountains of New York for over a dozen years. Through intensive field observation and close to 40 porcupine-years of radiotelemetry data, Roze has gained personal insight into most aspects of porcupine life. He describes general biology and life history in chapters on anatomy, foraging behaviour throughout the year, reproduction and maternal care, social structure, parasites, and porcupines of the world. He closely examines the winter den, defense strategies, relations with humans, and the infamous salt craving that is at the root of many human-porcupine interactions. He constructed a salted version of a gingerbread house specifically to study this salt drive in detail. His text is generously and effectively supported with numerous line drawings, figures, and black-and-white photos. All scientific tables are compiled at the end of the book, which may please or annoy some readers. Roze makes effective use of a substantial reference list to enhance, elaborate, or substantiate his discussion.

The academic content is intriguing and accessible to even the general reader. Scientific discussion is linked with passages of journal-like writing that together unravel porcupine ecology. Much of the information is based on original, unpublished data. His integration of personal observations underscores the importance of keeping field notes and is a lesson for every naturalist. Roze guides us through his own search for answers and then leads us to develop further questions and ideas for future study. Readers will find answers to obvious questions regarding quills and defense strategies, but you may also find many relevations. Why, for example, do so many porcupines sport skull fractures and broken bones? Why is this rodent's productivity so low — usually only one young per year?

The answers to many of Roze's questions lie in the forest itself. The porcupine is our field guide to phenology, nutrient budgets, tree communities and other aspects of forest ecology. In Roze's words: ". . . the porcupine has been a teacher, a storyteller of the woods, a complexifier and adorner of the world".

I don't think Uldis Roze was looking for porcupine-converts when he wrote this book, but he has one now. I highly recommend this publication to anyone interested in wildlife or forest ecology.

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Encyclopedia of Paleoherpetology: Anomodontia, Part 17C

By Gillian K. King. 1988. Gustav Fischer Verlag. Distributed in North America by VCH Publishers, Deerfield Beach, Florida. xii + 174 pp., illus. U.S. $147.00

The members of the suborder Anomodontia are Permian and Triassic mammal-like reptiles including, in King's review, the four infraorders Dinocephalia, Venjukoviamorpha, Dromasauria, and Dicynodontia. The taxa are linked by the loss of coronoid bone(s), non-terminal nostrils and long posterior spur of the premaxilla, grooved or troughed palatal exposures of vomers, and reduction or loss of the internal trochanter of the femur. In this monograph, King has gone far beyond a review of the available fossil material and has provided what appears to be well-corroborated cladograms within the anomodontia down to the level of subfamily. The review is very thorough and forms a most significant contribution to the evolution of these reptiles. As is typical of this type of review, there is a historical overview, comments on the development of the taxonomy of each group, and a systematic review. For each of the infraorders, King has provided information on the general osteology, functional anatomy, origins and evolution, mode of life, and geographical and geological distribution.

The work is academically very sound. Although it is sound, and the line drawings clear and of high quality, this work is definitely not for those with a casual interest in mammal-like reptiles because of its highly technical nature. For those with strong academic interests, there is only one unfortunate drawback to the monograph, the cost. For a paper-bound book, the price will be too steep for indivi-

dual researchers and even for many university libraries. For this reason alone, I can only recommend that the work be ordered through university libraries, or obtained and reviewed via interlibrary loan.

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Middle American Herpetology

Jaime Villa, Larry David Wilson, and Jerry D. Johnson. 1988. University of Missouri Press, Columbia. xxxvi + 132 pp., illus. + plates. U.S. $35.00 (+ $2.50 handling).

The diversity of amphibians and reptiles in Central America, is the richest in the World with 782 species currently recognized, and undoubtedly more to be discovered. This diversity results from the complexities of the interactions of taxa from North America and South America after the mid-Pliocene connection, with taxa evolving *in situ* in Central America. A high incidence of endemism is afforded by extreme physiographic diversity with every imaginable habitat and microhabitat ranging from cool, wet high elevation forests, to hot, dry lowland thornscrub. As a consequence of this variability, and the virility of the Organization for Tropical Studies in Costa Rica, the region has received much attention, although little in the way of syntheses. *Middle America Herpetology* provides the data base for the synthesis.

Villa, Wilson, and Johnson have compiled a list of, and assembled an index to, the herpetofauna of Central America and the associated literature. The region covered in the survey is from the Isthmus of Tehuantepec, Mexico south to the border of Colombia and Panama. The listings for each species include the "key literature," references to illustrations (including notation of colour or black-and-white), and region-by-region literature citations for the nine regions covered (Central American countries plus the Yucatan peninsula and south east Mexico).

Although the book does not contain a key to the taxa, referrals are made to the literature assisting in the identification of specimens. There are 91 colour figures and several black-and-white, many of rarely seen or figured specimens. The limited text is provided in both English and Spanish.

Typographically, the volume is exceptionally clean. Few mistakes occur, the only one of any significance being a misspelling of, and missing reference for, the description of *Ctenosaura oedirhina* (misspelled as *oeirhina*: de Queroz, Copeia 1987: 892–902); the presentation format for this species is unique.

Comparatively, no other volume comes close to *Middle America Herpetology*. The *Catalogue of Neotropical Squamata* (Peters et al., 1970, U.S. National Museum Bulletin 297) provides keys only to part of the region, and many of the keys to species are difficult to use at best. Savage and Villa's (1986, Society for the Study of Amphibians and Reptiles) *Introduction to the Herpetofauna of Costa Rica* provides an in-depth treatment of this herpetofauna, including keys to the species, but rapidly diminishes in utility the further away from Costa Rica that one gets, because of endemism.

Middle American Herpetology will be an indispensable reference for anyone interested in the herpetofauna of southern Mexico to Colombia. The authors are to be congratulated for producing such a valuable volume.

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The Complete Illustrated Atlas of Reptiles and Amphibians for the Terrarium

By Fritz Jurgen Obst, Klaus Richter, and Udo Jacom. (Contributions made by W.-E. Engelmann, K. Eulenberger, and H. Kohler. Translated from German by U.E. Friese; English-language edition edited by J. G. Walls). 1988. T. F. H. Publications, Neptune City, New Jersey. 831 pp., illus. + plates. U.S. $100 + $5 shipping.

The *Atlas*, originally published in German under the title of *Lexikon der Terraristik und Herpetologie*, is a massive book surveying virtually all recognized genera of amphibians and reptiles. The taxa are presented in a strict alphabetical order, facilitating quick location. In addition,

many invertebrate taxa which are frequently used as food items for amphibians and reptiles, or as pets, such as "Arthropoda" (crabs) and "Hymenoptera" (wasps), are also included. Numerous colour photographs have been added to the *Atlas* edition, and most of the line drawings have been eliminated.

Many of the photographs used in the *Atlas* have appeared in order TFH books. Unfortunately, this book appears to have been too hastily put together for several photographs appear upside down or sideways, many are of poor quality being out of focus or poorly exposed, numerous are highly redundant and unnecessary, such as five for the alligator lizard, *Gerrhonotus multicarinatus*, and some are misidentified (e.g., *Varanus prasinus* identified as *V. griseus*).

Comparatively, nothing comes close to the *Atlas* in terms of overall completeness. The great number of photographs, mostly in colour, will aid in the identification of taxa. However, because of the strict alphabetical organization, one may find themselves leafing through the 800+ pages in search of the identification of a single species unless they have some information on the specimen. The "Common Names" index may assist greatly in such a search. Novices, and perhaps even most professional herpetologists, will find the volume valuable.

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Reproductive Success: Studies of Individual Variation in Contrasting Breeding Systems

Edited by T. H. Clutton-Brock. 1988. University of Chicago Press, Chicago. 538 pp., illus. Cloth U.S.$75.00; paper U.S.$29.95.

Studies of lifetime reproductive success of individuals are of critical importance to behavioural ecology and evolution. Of particular interest has been the cause(s) of variation among individuals. Clutton-Brock's introduction poses four questions: 1) How widely does breeding success vary between individuals of a species; 2) How much of the variance in success is contributed by survival to breeding age, life span, fecundity, and offspring survival, respectively; 3) To what extent does reproductive success change with age; and 4) What environmental, phenotypic, developmental, or genetic factors affect breeding success in each sex? There follows analyses that attempt to answer these questions about the reproductive success of 5 insects, 2 amphibians, 12 birds, and 6 mammals. These 25 chapters are authored by 51 researchers. Two theoretical contributions and a summary chapter complete the volume. Two chapters are based on research done in Canada. Lesser Snow Geese at Churchill are the subject of a chapter by F. Cooke of Queen's University, and Song Sparrows on Mandarte Island by J. Smith of UBC.

The emphasis is on studies that monitor the reproductive success of individuals throughout their life. Most studies then look for correlations between an individual's phenotype and relative reproductive success. Offspring survival was shown to be an important component of reproductive success in several species. As expected sex, size, and age were also correlated with reproduction. An interesting exception was the Song Sparrows. No phenotypic correlations with number of offspring were found nor was reproductive success found to be heritable. The wealth of data presented on lifetime success shows that estimates of reproductive success and fitness based on a cross sectional sample must be treated with caution. Short term environmental changes and age effects were shown to be important in several species and short term studies have difficulty factoring these out.

It is a difficult task to follow individuals for a lifetime and monitor reproduction and none of the studies was able to answer all four of Clutton-Brock's questions. It should be easiest for short-lived, sedentary animals. Surprisingly a large proportion of the species studied are long-lived (e.g., Snow Goose, Elephant Seal, Vervet Monkey, Lion, Scrub Jay). All of the studies have some shortcomings, either lack of following individuals through life (Snow Geese), no data on offspring survival (insects and frogs), or no data on heritability (most studies). Despite this, all make a good attempt at answering one or two of the questions and leave the reader with new ideas and information.

Grafen's theoretical chapter on the uses of this type of data is good. It contrasts adaptation and selection in progress. There are two flaws. It does not explicitly address the previous chapter by Brown on calculating the components of reproductive success. Also, it does not deal with any of the other chapters in the book. It would have been more useful and interesting as a critique or review of the rest of the book. It stands as a theoretical examination of the concept in a book full of data.

Pictures, of all except one of the species, are a welcome addition to an academic book. The omission, *Drosophila melanogaster*, is interesting, lending credence to the rumour it is not a real organism just a well studied gene sequence map.

This is an academic book for researchers in behavioural ecology. However, it is quite readable and contains a wealth of useful information. Any naturalist writing a popular article or with a serious interest in bird, frog, or dragonfly natural history would do well to peruse this volume.

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Field Guide to the Birds of Java and Bali

By John MacKinnon. 1990. Gadjah Mada University Press, Yogyakarta, Indonesia. 391 pp. illus. c$17.

This version is listed as a reprint of the original 1988 publication. The first printing was plagued with a number of problems (four toes on a three-toed woodpecker, for example). These gross errors have been eliminated and the book has been updated so it is it bit more than just a new printing. However, the book still does not match current western standards. The artwork is variable in quality and lacks the crispness and detail we now expect in a modern guide. The printing in my copy is adequate but the buyer needs to choose carefully to avoid out-of-register plates. The text is clear but very spartan and provides only limited help in separating species.

It is still the only guide to Java and Bali and includes species not covered in King et al.'s *Birds of South-east Asia* (the most widely used guide in this region). The cost is the equivalent of about $17 Canadian in Jakarta. Doubtless it will be more expensive here.

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Birds to Watch: The ICBP World Check-list of Threatened Birds

By N. J. Collar and P. Andrew. 1988. ICBP Technical Publication No. 8. Smithsonian Institution Press, Washington, D.C. xvi + 303 pp. U.S. $18.95.

If we as human beings continue to alter all corners of the earth, we must bear the responsibility of the consequences. With so many species vital to so many ecosystems, monitoring these consequences may prove almost impossible. *Birds to Watch*, however, is a step in the right direction.

Published by the International Council for Bird Preservation and the Smithsonian Institution, this book represents an inventory and status summary of all of the world's birds currently regarded as at risk of global extinction. It stems from two editions of loose leaf *Red Data* books that contained lists and information on the status of endangered species since the mid 1960s. The current volume, *Birds to Watch*, is a more comprehensive treatment, containing 1000 species, or about 11% of the world's birds. Despite this seemingly large number of birds, the information in this book is described as "an understatement of the true global situation" by ICBP director Christoph Imboden.

Imboden begins the book with an interesting and well-written foreword, followed by a brief introduction by the authors. An annotated list of the world's threatened birds comprises over half of the book. This list, given in taxonomic order, presents brief descriptions of the habitat, distribution (countries in boldface), populations, as well as threats and declines affecting the birds. Numerical abundance is given where this information was available. Otherwise, abundance scales (ie. common, rare) are used. Although precise definitions of these terms are not presented, the reader can still get a general idea of the population size.

A comprehensive bibliography of the citations in the list is given, followed by two appendices. The first is a list of the threatened birds described earlier, sorted by geopolitical unit (usually countries). This is a very useful addition, singling out countries that must take actions towards conservation. The second appendix contains near-threatened or "borderline" species of birds, such as the Hudsonian Godwit, *Limosa haemastica*, and Henslow's Sparrow, *Ammodramus henslowii.*

Indexes of both English and Latin names are found at the end of the book.

Although this book is little more than a reference list of endangered birds, its function and potential impact reach far beyond. As the ICBP director puts it ". . . the well-presented plight of an individual flagship species . . . [is] still one of the best ways of concentrating public attention on broader environmental problems." The popularity and knowledge of birds make them particularly good candidates for this. Threatened ecosystems where very few species of other classes of animals are known, can be acknowledged and saved through the recognition of one endangered habitant bird species.

Looking at this book in this light, we see its value in the identification of endangered ecosystems around the world. And after all, identifying the problem is the first step.

I found this book informative and interesting. It is a book that no ornithologist interested in conservation should be without. It is, however, a book that will be outdated rapidly. I sincerely hope that the authors continue to produce updated lists of such high quality, so that we may continue to monitor the endangered birds and ecosystems of the world.

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BOTANY

Buttercups, Waterlilies, and their Relatives: (The Order Ranales) in British Columbia

By T. Christopher Brayshaw. Royal British Columbia Museum Memoir No. 1. 1989. Crown Publications Inc., Victoria. 253 pp., illus. $20.00.

The Royal British Columbia Museum, formerly the British Columbia Provincial Museum, is well known for its series of botanical publications of which *The Rose Family* and *The Figwort Family* by T. M. C. Taylor are two fine examples. The present publication, which treats the families Ranunculaceae, Nymphaeaceae, Ceratophyllaceae, and Berberidaceae is an excellent continuation of this series. Family and generic descriptions are provided and a total of 98 species, that are either native or well established, are described and illustrated. The descriptions and keys appear to be quite adequate to separate the various species that occur in the province and the comments on variation and distribution are most helpful. The full-page line drawings with details of the floral parts, all drawn by the author, are welcome companions to the text. Ephemeral species, that may rarely be encountered as escapes or persist after planting, appear in the keys but are not described in detail. Common names and synonymy are also given. Chromosome numbers are given where known for the various species but unfortunately there is no indication as to whether or not they are based on British Columbia collections.

The introduction includes a definition of the group, a brief overview of the families of Ranales in British Columbia with comments on Material and Observations, Descriptions, Subspecific variation, Distribution, a Checklist, Excluded Species, and Nomenclatural Innovations. The latter are: *Anemone multifida* var. *saxicola* f. *hirsuta* (C. L. Hitchcock) Brayshaw (*A. multifida* var. *hirsuta*), *Ranunculus* × *heimburgerae* Brayshaw (*R. occidentalis* × *californicus*, *Ranunculus escholtzii* ssp. *suksdorfii* (Gray) Brayshaw (*R. suksdorfii*), *Ranunculus gmelinii* var. *hookeri* f. *prolificus* (Fernald) Brayshaw (*R. purshii* var. *prolificus*), *Thalictrum occidentale* var. *breitungii* (Boivin) Brayshaw (*T. breitungii*), *Achlys triphylla* ssp. *californica* (Fukuda & Baker) Brayshaw (*A. californica*) and *Berberis aquifolium* ssp. *repens* (Lindley) Brayshaw (*B. repens*). This is followed by notes on the Evolutionary Position of the Ranales and a Key to Families of Ranales in British Columbia.

A Glossary of Technical Terms, Illustrations of Plant Structures, Abbreviations and Symbols, and an Appendix of 97 distribution maps complete the volume.

This volume will be welcomed by both professional and amateur botanists interested in the flora of the province of British Columbia. Phytogeographers from even a wider area will find it most useful.

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Lichens, Bryophytes and Air Quality

Edited by Thomas Nash and Volkmar Wirth [*Bibliotheca Lichenologica 30*] J. Cramer, Berlin. 297 pp. DM 90.

Did you know that lichens and bryophytes are one hundred times more efficient than flowering plants at accumulating atmospheric pollutants like sulphur dioxide? Read on.

Lichens, Bryophytes and Air Quality is the end-product of a symposium held at Grand Forks, North Dakota in 1983. It is also the first comprehensive North American review of lichens, mosses and liverworts as bioindicators. Although its contents are now slightly out-of-date (most contributions cover only to 1985), it remains the most extensive summary of its kind.

Of the twelve authors who have contributed to this volume, only one, Keith Puckett, hails from Canada. Nevertheless, it is interesting to note that considerable research has been performed in Canada using cryptogams as environmental monitors. Indeed, Canadian bryological studies apparently account for more than three-quarters of all North American research of this kind, perhaps reflecting the dominance of bryophytes peculair to Canadian forest ecosystems.

The book is divided into twelve chapters, including two introductory chapters, four on pollution monitoring, four on physiology, and two on the application of lichen and bryophyte research to regulatory decisions. High points for naturalists include: Chapter 1, in which Tom Nash and Bob Egan provide a minicourse on lichen and bryophyte biology; Chapter 2, in which Nancy Slack summarizes the ecological importance of these organisms; Chapter 7, in which Ray Showman sums up the results of fifteen biomonitoring studies using lichens; Chapter 7, in which Bill Winner does more or less the same for bryophytes; and Chapter 9, in which Winner et al. compare the absorption capacities of lichens and bryophytes with those of flowering plants, as noted above.

In addition, the final chapter will be of interest to conservationists. Here Lorene Sigal, in an article on the relationship of lichen and bryophyte research to regulatory decisions in the United States, signals new avenues of research which would make these organisms more useful in establishing air quality standards. At the same time she paints a helpful portrait of American legislation on air pollution.

The last pages of the book are devoted to a full and useful index that I found easy to use. Though the editors have not seen fit to include a glossary, this omission is partly compensated for by Chapter 1, in which most of the necessary terminology is introduced in bold print. Especially valuable to prospective researchers are the bibliographies which accompany each of the chapters; collectively these represent a highly detailed who's who and what's what in pollution studies.

In summary, *Lichens, Bryophytes and Air Quality* is a well-appointed primer for researchers wishing to use lichens and bryophytes as indicators of atmospheric degradation. The methodologies outlined in its pages should enable even nonspecialists to design and operate inexpensive monitoring stations in their neighbourhoods. For this reason alone, *Lichens, Bryophytes and Air Quality* should be required reading for anyone who wants to keep a finger on the pulse of environmental health.

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ENVIRONMENT

Changing the Global Environment: Perspectives on Human Involvement

Edited by: D. B. Botkin, M. G. Caswell, J. E. Estes, and A. A. Orio. 1989. Academic Press (Harcourt Brace Jovanovich, San Diego). 458 pp., illus. Cloth U.S. $49.95; paper US $24.95.

Changing the Global Environment is a selection of papers from an international conference held in Venice, Italy, in October 1985, dealing with the relationship between people and nature. As a result the authors invited to contribute papers to the book are noted international authorities for the subject areas covered. Each paper is provided with a helpful introduction to the author and subject matter covered.

The stated purpose of the book is a retrospective view to consider what mankind has learned, what mankind might be able to learn, and might do in the future. A large portion of the book has been devoted to the development of remote sensing, its impact now, and in the future. There is some mention of analytical advances other than remote

sensing. Economic impact and implementation methods are discussed on a regional and global level. Examples taken from the authors' own work are provided throughout.

The book is intended "to lead a change in emphasis from negative to positive aspects of our abilities to manage our environment and from a local and regional to a global perspective." A statement found in a number of the papers is that localized and regional global changes, good or bad, do have a global effect. The positive aspect mentioned throughout the book is that mankind has the technology and knowledge to chose global change resulting in a better environment. The key question arising from the discussion in this book is "does mankind have the courage and fortitude to make the necessary changes to improve environmental conditions?"

Changing the Global Environment would be a useful reference as well as a source for further discussion. The book tries in no way to answer the environmental problems the world is presently confronted with, but does put forward possible means and methods that maybe useful in solving some problems. The method chosen will depend upon individual situations.

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A Neotropical Companion

By John C. Kricher. 1989. Princeton University Press, 41 William Street, Princeton, New Jersey. 436 pp., illus. Cloth U.S. $45; paper U.S. $16.95.

John C. Kricher has prepared *A Neotropical Companion* as an introduction to the tropics of Central and South America. His goal was to provide a readable introduction for "armchair travellers, field naturalists, and conservationists". In recent years the increasing visitation to the neotropics by naturalists has created a need for such a book.

The book discusses biological and ecological topics of most major ecosystem types in the American tropics. The concentration is on the moist and rain forests but savannas, mangroves, and coral reefs are also covered in some depth. Dry forests, cloud forests, paramo, and puna are only briefly covered. This ecosystem approach is effectively done, even with the differential level of coverage.

The best part of the book deals with a thorough, but readable, set of discussions on the ecosystem functioning, and its evolutionary underpinning, of the rain forests. Kricher does an excellent job of providing a balanced discussion of topics such as: diversity gradients, adaptive radiation, speciation, coevolution, and tropical selection pressures. He devotes a chapter to the complicated chemistry of the tropical plants and animals that has evolved for both attraction and repulsion purposes. His discussion of these topics leaves the reader with a visible sense of the author's appreciation and awe at the diversity and complexity of tropical life.

Kricher devotes one third of the book to the discussion of specific groups and species of animals. There is a thick chapter on birds. The most commonly observed mammals and reptiles are covered in some depth. Some amphibians and invertebrates are discussed. The purpose of these discussions appears to vary from basic descriptions to descriptions plus ecological roles. This is the poorest part of the book. The descriptions of many species are too sparse to give a fuller mental picture of the animal. Few are illustrated. The illustrations that do occur, all of which are black-and-white drawings, are of good quality. But many more are needed. For the tropical traveller this book must be read with many other books close at hand, so that the animals can be observed while Kricher discusses them. This is unfortunate because there are no field guides or other books that illustrate some of the species, most specifically the invertebrates.

The book contains many useful tips for the tropical traveller. Hidden in Chapter 2, entitled "A Rain Forest", is a handy section on safety in the tropics. Poisonous snakes, bullet ants, chiggers, roundworms, and other unpleasant beasties do occur. This section provides, from a traveller who has been there, a short but effective coverage of such issues. This section alone is worth the price of the book. Unfortunately, the table of contents of the book has chapter titles only and one must read the entire book to find specialized sections such as this.

The book mentions the ecological importance of plants throughout. But the lack of illustrations here, and of field guides generally, leaves the reader wondering what many of these plants really look like.

The author writes in a conversational tone. This makes the book much more readable than if text book prose has been used. The efficient review of

the literature and its careful referencing throughout the text actively leads the reader to other sources. The author has kindly provided an annotated list of most of the best books available in the field of neotropical biological science.

If a student, advanced naturalist or ecotraveller is going to visit the neotropics, this book should be read beforehand. It is long on tropical ecology but is short on travel details. For example, there is no coverage of clothing, handling the climate, currency, language, or transportation. The author seems to assume that the traveller has a guide with him that helps with such concerns. This assumption grows out of the situation in which the author often visits the tropics, as a teacher of students. He provides such details for the traveller students. For the travellers without such a teacher, a number of guides to specific countries are now appearing on the market.

A book that introduces the biology and ecology of the neotropics to the student and traveller has been needed for some time. *A Neotropical Companion* fulfils this ecotourism need quite well. It should sell well. Hopefully, future editions can build on this good start and make the book even more useful.

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Legacy: The Natural History of Ontario

Edited by John B. Theberge. 1989. McClelland and Stewart, Toronto. 416 pp., illus. $75.

This is a coffee-table edition which should instill both pride and an understanding of the need for conservation in every Ontario resident. Although it provides an excellent and comprehensive overview of the broad diversity of species and natural habitats in Ontario, it is written for the non-specialist. Its 93 short essays are adequate to peak the interest, but far from providing more than an introduction to any particular topic. The only shortfall that I would cite is the limited and somewhat dated 3 pages of references for further reading at the end. Perhaps a lesser complaint, and one which is reflective of the intended audience, is the limitation of material on the northern, more isolated part of the province.

The book is divided into five parts plus an introduction. These progress from the very general description of how Ontario fits into the planet as a whole, through the natural divisions of the province and a selection of special places that can be found, to selected essays on natural habitats and species and then conclusively, broad, philosophic discussions of nature and natural values. I personally found it easier to first leaf through and selectively read articles of specific interest, rather than read the entire book from start to finish. In the end, though I found all of the articles interesting, worthwhile, and highly readable.

Typically, John Theberge can only be praised for the effort he has personally put into this endeavour. Not only has he edited the entire publication, keeping the 43 other authors on topic in an interesting and yet concise and readable manner, but he has also written over a third of the materials himself. The photographs are excellent and inspiring. Where necessary, these are expertly supplemented by maps or the sketches from Mary Theberge. I think that the Theberges have succeeded in the goals of the book: "to appease curiosity; to create 'feelings of nature' through description, art, and photo; and to deepen a sense of beauty, excitement, and wonder". It is nice, in this age of often justifiable feelings of environmental gloom, to read such well documented evidence of the beauty of nature which surrounds us. I certainly recommend this book both to experienced naturalists, as documentation of what they have begun to understand and to those who wish an introduction to the many areas of nature which are still available to explore in Ontario.

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The Atlas of Natural Wonders

By Rupert O. Matthews. 1988. Facts on File, New York. 240 pp., U.S.$35; $45 in Canada.

This is a photographic sampler of 54 of the world's more fascinating places. It includes some that will be familiar to most people (Mount Fuji, Ayers Rock, Ngorongoro Crater, Grand Canyon), and some that will not (Lake Vänern in Sweden, the Band-e Amir Lakes in Afghanistan, Cheddar Gorge in England). Each main entry is given four pages of text and photographs. The text takes various forms, but is usually effective in evoking the spirit of the place through a combination of facts and anecdotes. The photographs, about half of which are in colour, are uniformly attractive. The main entries are supplemented by a short Gazetteer with brief details on another 44 places, and 63 of the world's national parks. It seems to have been an afterthought, and does not add much to the book.

Canada is represented by one main entry (Niagara Falls), one Gazetteer entry (Rabbitkettle Hotsprings), and four national parks (Wood Buffalo, Nahanni, Kootenay, and Banff). Western Europe and the southwestern United States account for a large proportion of the entries. Places are listed in longitudinal order, west to east, which leads to some curious sequences (Niagara Falls, the Amazon River, and Greenland one after the other for example). If there is any logic to all this it is obscure, but it doesn't really matter. This is a book for browsing, and all the entries are fascinating. It should appeal to most armchair travellers.

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Matrix Population Models: Construction, Analysis, and Interpretation

By Hal Caswell. 1989. Sinauer Associates, Sunderland, Massachusetts. 328 pp., illus. Cloth U.S. $50; paper U.S. $28.95.

Since matrix population models first appeared in the 1940s, their use by population biologists has grown steadily. They have been especially useful in modelling populations where the life cycle is best described by discrete variables like developmental stages rather than continuous variables like age. This is an advantage over differential equations that require continous variables. Other advantages of matrix population models include: 1) easier model construction, 2) greater adaptability to complex life cycles, and 3) greater accessibility to a wide audience (linear algebra can be learned more rapidly than calculus).

Early in this book, the important distinction is made between projections that these models can make and predictions which these models can not make. Many examples are used to illustrate the construction and analysis of time-invariant, density-dependent matrix models classified by age or size or both. A chapter on life cycle graphs demonstrates how important properties of matrices can be derived directly from life cycle graphs. Then several methods of sensitivity analysis and statistical tests of differences between matrices are presented. The final chapters explore advanced topics including stochastic models, density-dependent models, and frequency-dependent two-sex models.

This book contains numerous examples from animal and plant population biology that are presented with many well-done diagrams and graphs. A concise review of linear algebra is presented in the appendix. Knowledge of calculus is not required to understand the matrix operations in this book; however, it would help the reader appreciate how matrix models are related to continuous functions. Still, many readers will need to go through this book with pencil and paper in hand in order to keep up with the very clear but fast flow of ideas. Nevertheless, this is a landmark book in the methods of population biology, and I highly recommend it to all students of population biology.

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State of the World 1989: A Worldwatch Institute Report on Progress Toward a Sustainable Society

By Lester R. Brown, et al. 1989. Norton (distributed by Penguin Books Canada, Markham, Ontario). xvi + 256 pp. $12.95.

Here we have the newspaper and radio headlines of 1988 condensed into an excellent paperback book of ten chapters: A World at Risk; Halting Land Degradation; Reexamining the World Food Prospect; Abandoning Homelands; Protecting the Ozone Layer; Rethinking Transportation; Responding to AIDS; Enhancing Global Security; Mobilizing at the Grassroots; and Outlining a Global Action Plan. There is no need to abstract the dreary data here, they are of the kind which has been all too familiar during the last century and a half. The chapters are well documented in 49 pages of notes which refer, however, more often to newspaper articles and shadow literature than to the refereed literature, which is probably inevitable in dealing with such current affairs.

The Worldwatch Institute is in Washington, D.C., and there is little mention of Canada here. Canada is often missing from tables of "selected countries," and gets its only significant coverage for the promise of its Prime Minister to reduce net Canadian carbon dioxide emissions by 20% by 2005. As it came to pass, this luminary used 1989-1990 for anachronistic ethnic squabbling which resulted, in addition to complete inaction on ecological matters, in the resignation of his minister responsible for carbon dioxide.

The year 1989 was, in fact, celebrated for the end of the Cold War, which was the aftermath of the Hitler War, which was the aftermath of the Great War, which was the aftermath of the failure to heed prophesies of social breakdown at the end of the last century. If we have only a decade to turn society around, as this volume asserts, it would seem that we will come up short by about 79 years.

Is it too much of a coincidence, though, that ecological doom is to fall exactly 10^3 yr after the last millenial panic? Has the long succession of little congregations disappointed on hilltops by their miscalculations of prophesies of the Roman sack of Jerusalem made modern commercial culture unresponsive to all apocalyptic foretellings? Are the products of natural selection so radically premised on the continuation of past conditions that human foresight and scientific extrapolation are incapable of significantly influencing human behaviour? Are governments so sated with wars and constitutions that they are incapable of taking ecological questions seriously?

I fear that all these questions are to be answered in the affirmative. Tomorrow I will be able to take stuff to the township dump and for the first time some of it will be recycled rather than buried. This is the kind of reform *State of the World* calls for. It seems too little too late; let us hope there is a miscalculation somewhere.

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Desert Solitaire

By Edward Abbey. 1988. The University of Arizona Press, Tuscon. 300 pp., illus. U.S. $24.95.

"Books are like bananas, best when fresh". Edward Abbey quotes Jean Paul Sartre in the Preface to this reprint of his classic book. Perhaps he included this quote as a contrast to his book, after more than 20 years this book is still fresh. A journal Abbey kept during the summers of 1956 and 1957 while he was a seasonal ranger at Arches National Monument in Utah is the basis of the book. Originally published in 1968, this new version has benefited from minor editing. Surprisingly it does not sound dated, perhaps because a central theme is a questioning of the values of middle America. Many of the values have not really changed; any nipping at the heels of the smug majority sounds fresh.

It is a hard book to classify. The book is about how humans relate to a wild environment, to a park, and to other humans. It is popular, or more appropriately campfire, philosophy. Nature writing is not the correct classification, because although there are descriptions of the vegetation, fauna, rocks, and weather, they form a backdrop, not the main thrust of the book.

People have an interesting place in the book. Some are disdained, such as the tourists he toys with as a ranger. "'Any dangerous animals out here, ranger?' 'Just tourists' (Laughter; tell the truth and they never believe you.)" They lack his deep respect for the area as it is, his desire to experience the area, without the buffer of cold Coke, paved roads, and flush toilets. Abbey doesn't understand their desire for easier access so

that they won't have to stay as long or duplicate any view. He knows the constantly changing view from one spot, through a day, through the seasons, from year to year. He knows that viewing the area this way may be less comfortable, but much more rewarding.

People are also revered, if they are different from the rest. The Spanish cowboy, the miners in the bar, and his rancher friend are all portrayed with deep respect. Independent types with the strength of conviction to travel their own road are well treated. Presumably Abbey is measuring his strength and his conviction against them. The rambling narrative attempts to shock the average person and question the conventional view. This book is like the yelling of a disgruntled, idealistic teenager saying: look what you are doing, there are better, more interesting ways of living. Abbey questions the values of people, sometimes by ridicule, sometimes by flagrantly advocating the opposite, sometimes by putting outcasts on a pedestal.

A diffuse argument for leaving some land wild runs throughout the book. Wild land is of great benefit, even essential, for some people. It is also not for everyone. He argues that the people in RV's, who do not want to get too hot or thirsty or their feet wet, can always find somewhere else to go, but those who enjoy wildlands have a limited selection. Therefore it is necessary not to pave the road to every attraction in every National Park. The chapter entitled "Polemic: Industrial Tourism and the National Parks" emphasizes that this argument is not dated. Increasing development of some National Parks in Canada could very easily be substituted for the details of the southwestern United States in the 50s and 60s. Banff is a great spot to drive through, see some mountains and animals. Do many make the effort to experience more? Which group should National Parks be catering to?

Who will enjoy this book? Anyone who questions the mainstream value of comfort before experience, malls before wild lands, will. This is a thought provoking book. There are enough one liners to keep you reading through the next chapter, enough interesting ideas to keep your mind working. I am not sure whether inside beside a crackling fire on a cold rainy day or outside under a blistering hot sun is the appropriate place to read it. It probably doesn't matter.

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MISCELLANEOUS

Axis and Circumference: The Cylindrical Shape of Plants and Animals

By Stephen A. Wainright. 1988. Harvard University Press, Cambridge, Massachusetts. x + 132 pp., illus. Cloth.

A resurgence of scientific debate on the sizes and shapes of organisms has occurred over the last decade. The concensus of a wide variety of authors has been that the size of organisms is an integral and important aspect of their biology: there are ecological and evolutionary consequences to particular body sizes. Not as much attention has been paid to the consequences of shape, despite the efforts of D'Arcy Thompson (almost 50 years ago) to show that organism shape changed with size. One of the few voices speaking out about form and the consequences of body shape belongs to Stephen Wainright.

Dr. Wainright, a zoology professor at Duke University, has a special interest in biomechanics. He typically asks questions which relate the material composition of organisms to the physical stress and strain which they face as a consequence of their particular mode of life. His new book begins with the simple statement that "The bodies of multicellular plants and animals are cylindrical in shape". Wainright asks what functional or selectional advantage a cylindrical body shape confers on organisms and species over evolutionary time.

After some preliminary definition of the scope of the book, Wainright proceeds to describe the essential importance of the form and structure of organisms to their function as mechanical support systems. The mechanical properties necessary for function, the role of stress and strain, and the influence of size and time scales on the forms which organisms take are introduced here. An in depth examination of the mechanics of shape forms the basis of the second chapter. Wainright is at his explanatory best here, within the realm of his specialty. The relative merits, both advantageous and disadvantageous, of one-, two-, and three-dimensional shapes are examined with discussions centering on the mechanical benefits which the properties of cylindrical cross-sectional shapes can provide.

Next, Wainright tackles the problem of materials and their mechanical properties, a subject in which he has a respectable reputation already (the 1976 book for which he was senior author, *Mechanical Design in Organisms*, has provided a standard which other works have yet to match). Wainright has outdone himself in the ease with which he explains some difficult concepts — difficult for non-engineers at the very least. The chapters on mechanics and material properties provide the necessary basis for the "meat" of Wainright's thesis: how do structural systems of cylindrically shaped elements confer selective advantages on organisms?

The origin and possible evolution of cylindrical body shape are presented in a similarly forthright and logical manner. Wainwright's hypothesis grades features in an ascending hierarchy where each new feature depends on the previous. Intercellular adhesion, dependant on the development of extracellular polymers, allows for the development of a variety of material stiffnesses *via* polymer cross-linking. Cross-linking, in turn, provides for the development of anisotropy (for example, mammal leg bones are anisotropic — they are stronger along their length than they are across the thickness) by allowing fibres to become oriented parallel to each other. Cylindrical body shape is a result of polarity in parallel oriented fibres.

After a brief foray into the realm of alternative body forms (more detail could have been given to the relative advantages of other ways of life, even if it were given only as further evidence for the hypothesis), Wainright examines the shapes and forms of modern animals and plants. The conclusion that shape is a factor of considerable importance in the everyday lives of organisms, as well as accounting in no small way for their evolution, is inescapable.

The production of the book was well conceived. The page layout, binding, and overall appearance contribute to a good first impression. The figures are especially noteworthy: all are clean, easy to read, and impressive for their simplicity — they actually aid in the comprehension of the ideas. Wainright provides a useful assessment of his main points at the end of each chapter. These serve to accent the points themselves, as well as the coherence of the ideas. The book is admirably suited to students beginning study of life sciences at the undergraduate level, yet still retains much of usefulness for the interested researcher.

Since the modern trend to consider organism size as a factor some consequence in the life history, ecology, and evolution of organisms has begun, we have needed a comprehensive treatise on the concommitant attribute of shape. Stephen Wainright has given us just what the doctor ordered.

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Studying Animal Behavior: Leaders in the Study of Animal Behavior

Edited by Donald A. Dewsbury. 1989. University of Chicago Press, Chicago. 512 pp., illus. U.S. $19.95.

It is sometimes claimed that with the exponential rise of science most of the researchers involved in the entire history of the enterprise are still alive. This may be, but obviously cannot remain so for long. Those interested in the recent development of such disciplines as the study of animal behaviour are therefore indebted to the efforts of Donald Dewsbury and others who have collected reminiscences from older contributors while they are still with us. Dewsbury is the foremost historian of animal behaviour, and beyond his published work his omnipresent camera is well known on the conference circuit. The book contains alphabetically-ordered autobiographical accounts and portraits from 19 men (Baerends, Dethier, Eibl-Eibesfeldt, Fuller, Griffin, Hediger, Hess, Hinde, King, Leyhausen, Lorenz, Manning, Marler, Maynard Smith, Richter, Scott, Tinbergen, Wilson, and Wynne-Edwards) from the United States, United Kingdom, and Continental Europe based on a list created by a committee. As Dewsbury admits, any such list is bound to be controversial, and indeed a more physiological and less ecological perspective would have resulted in changes.

As would be expected, almost every essay is a joy to read, apart from the defensive tub-thumping of Leyhausen. There is a pleasing mix of personal and professional recollections with varying candidness and some delightful anecdotes and asides. Recurring themes include the importance of childhood natural history and of travel, the inevitable impact of World War II, the fruitfulness

of interdisciplinary contacts, and the typical lack of overt religious impetus. Major issues receiving discussion are the Lorenz-Lehrman debate on nature and nurture, behavioural genetics, human ethology, sociobiology, and studies in communication and orientation. The essays also reflect the sociological rise of the discipline including the development of evolutionary biology generally, the establishment of journals and conferences, and the involvement of these researchers in general education, especially film making. For anyone interested in animal behaviour or intellectual biographies this volume is excellent reading, and Dewsbury is to be congratulated on it. It is intriguing to speculate how women and some countries, conspicuously absent from the present book, will be represented in a subsequent one a generation hence.

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Journal of a Barrenlander, 1928-1929

By W. H. B. Hoare. Edited and annotated by Sheila C. Thomson. 1990. Published by Sheila C. Thomson, Box 4435, Postal Station E, Ottawa, Canada K1S 5B4. 186 pp., illus. $24.95.

W. H. B. Hoare had substantial travel experience in the western Arctic, could speak Inuit and understood the lifestyles of both the Inuit and northernmost Indians, and was also a remarkable all-round mechanic. In January 1928, assisted by A. J. Knox, a warden from Wood Buffalo Park, he undertook a general investigation of the Thelon Game Sanctuary for the Department of the Interior. He was required to take two years' supplies and also much of the material needed to build a warden's cabin at an appropriate site in the sanctuary. They were thus heavily laden even on level ground and seriously overloaded for the uneven high country. They had a single team of five Eskimo dogs, and repeatedly had to shuttle back and forth with divided loads. They really should have had two teams, but fish proved so scarce in the Hanbury highlands that it was difficult to keep one team going. The worst problem of all was that they were misled by the most recent (seriously erroneous) official map into taking a southerly route, by Ford and Campbell lakes, into the Hanbury system, rather than the proven route along Artillery Lake, up Lockhart River, through Ptarmigan Lake, and, with a few relatively short portages, into the upper Hanbury River. Examination of the modern topographic maps, based in large part on vertical aerial photography and radar altimetry, makes it astonishing that they survived. In addition to the major lakes (now correctly positioned) there are countless little lakes. The lakes are mostly between 350 and 390 m above sea level. The intervening land often runs over 400 m but is without high hills that might have broken the wind. It is hard to imagine worse country to traverse in mid winter with overloaded sleds and under-nourished men and dogs, for they were in the belt of WNW prevailing winds that stretches from the western Mackenzie coast to and across Hudson Bay. Because of this wind pattern Chesterfield, on the coast, has a severer January wind chill than any station in the arctic islands. That they reached the Hanbury in awful weather across this mismapped country is a tribute to the stamina and skill of both men.

Just what are the Barren Lands? The term has been criticized because the land is not completely lifeless; but barren usually means unproductive in terms of forestry or agriculture, which aptly describes the Barren Lands. In Collins English Dictionary (2nd edition) they are defined as "the region of tundra in N. Canada, extending westward from Hudson Bay: sparsely inhabited chiefly by Inuit." It is, of course, a descriptive rather than a political term, and so we need not precisely define its boundaries. The term is apt in another sense, for until vertical aerial photography came into use after WWII maps of this huge area (including most of Keewatin and much of eastern Mackenzie) were featureless except for a coastal strip and the Back, Hanbury, Thelon, Dubaunt, and Kazan rivers and lakes along them. Summer travel was practically all by canoe, which allows a very limited lateral field of view. Well, our maps are no longer blank, for the region is riddled with small lakes, but to northerners the term is still meaningful. As a piece of our history it should be preserved, just as we keep most of our Fort place names although the stockades are long gone.

The Barren Lands were heavily glaciated and relatively late in deglaciating. With cool summers there has been little new formation of mineral soil. A peculiarity of the region is that even far beyond the continuous tree line small clumps of spruce (*Picea glauca* and *P. mariana*) are found. It seems

certain that these clumps have persisted ever since the end of the Hypsithermal Interval when the limits of trees and other plants were driven several degrees southward. They seem all to be on sites sheltered to the west and northwest. Probably few of the trees on the least protected sites ever set seed; but they spread by tillering of the lower branches, so that each finally forms a clonal colony whose stems combine to reduce wind speed and protect the winter buds from snow abrasion. Of all the factors that limit the spread of spruce into the barrens, by far the most important in this region is wind-driven winter snow, which consists mainly of small sharp crystals. The surviving trees are sheltered by river cutbanks, eskers, or hills. Probably the finest grove is the one on the left bank of the Thelon where Hoare and Knox built the warden's cabin. I judge from the photograph on page 97 that most of the trees are fully 10 m tall. The grove is on an extensive gravelly beach and is shielded on the northwest side by hills that seem to be up to 100 m high. Here catabatic warming of the prevailing wind must somewhat enhance plant growth, for we know that under marginal conditions a rise of less than a degree in the July mean temperature may double the number of plant species and conspicuously increase their sizes. Most other spruce mentioned by Hoare were small, misshapen, or with broadly triangular trunks indicating very small annual growth.

My own interest in the region started in about 1948, when I volunteered to do botanical work with the Northern Insect Survey. It was then that I read some of the early accounts, including those of the Tyrrells and C. H. D. Clarke. Thus I learned something of Hoare's work only after his untimely death. However, his daughter Sheila joined the Division of Botany at Ottawa at about this time, and I gradually became infected by her enthusiasm for her father's work; but only now, from his unabridged journal, have I recognized the full extent of his achievements. This is not a glamorous adventure story, but the stark and sometimes telegraphic account of a man working under often appalling conditions to do his job. This diary, lovingly edited by his daughter, is a significant contribution to the history of exploration of our northlands. Nothing that I could write would enhance Hoare's account, but I shall comment on a few items.

I suggest that, for a first reading, a reader unfamiliar with the region follow the route map on page 174. To understand their problems in the essentially unmapped Hanbury highlands see the portions of the modern topographic map on pages 59 and 92.

On 8 June 1928, when they were at ca 400 m, Hoare reported the first mosquito, which would be only three weeks later than the average date at Ottawa. I finally realized that he must have seen a species of *Diamesa* midge such as we see in April at Ottawa emerging from snow-melt streams. I find no mention of mosquitoes that summer in the highlands. In contrast, in the diary for 7 July 1929 onward, along the lower Thelon, their maddening attentions were repeatedly noted.

There is repeated reference in the diary to a feature, Hawk Rook, below Helen's Falls on the lower Hanbury. It is a conspicuous glacial erratic slab (*fide* Sheila Thomson). Dr. Denis St. Onge suggests that Rook is abbreviated from Rookery and used also for the site of a single nest. Possibly in Tyrrell's day a Rough-legged Hawk or a Peregrine Falcon nested on the rock.

The lower Hanbury is extremely fast. In less than 30 km it drops some 115 m in a series of falls and rapids. During deglaciation it must have been a huge torrent, bringing down great quantities of sand. After meeting the Thelon it presumably slowed down enough to deposit most of its load; and I suspect that the bench which allowed the excellent tree growth at Warden's Grove is such a deltaic deposit. However, the sand ridges mentioned occasionally must be eskers, which are common in the region.

In 1929, White-crowned Sparrows and (Common?) Redpolls nested freely in the trees at Warden's Grove. Both species prefer to nest in trees or shrubs, but will also nest in open tundra. Thus I see no way of telling whether there have been nesting populations in this grove ever since the tree-line retreated or whether it was rediscovered by migrants at some later date. The limits of some arctic species do change strongly with fluctuating summer weather.

I have two minor criticisms of Hoare's entire operation: The supplier of his canoe motor should have supplied spare shear pins for the propeller shaft; and I am surprised that Hoare did not know the Inuit practice of making mukluks for the dogs to wear in icy spring snow. (They apparently work well if you can fit the last dog before the first one eats his!)

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NEW TITLES

Zoology

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Cover: A Musk Turtle (or Stinkpot), *Sternotherus odoratus*, captured at the outlet of McLaurin Bay, Quebec. See Chabot and St. Hilaire, pages 411-412. Photograph courtesy Jacque Charbot, Ministère du Loisir, Chasse et de la Pêche, Hull, Quebec.

The Canadian Field-Naturalist

Volume 105, Number 3 July-September 1991

Range Extensions and Rare Vascular Plants from Southeastern Yukon Territory

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Rosie, Rhonda. 1991. Range extensions and rare vascular plants from southeastern Yukon Territory. Canadian Field-Naturalist 105 (3): 315–324.

Seventy-two species of vascular plants collected since 1973 from the Frances Lake area and several other locations in southeastern Yukon Territory are reported. Fifty of these species constitute range extensions of the maps presented in Hultén's (1968) *Flora of Alaska and Neighboring Territories.* Twelve species lie within their predicted ranges but are considered rare in Yukon Territory. Ten species are both range extensions and rare.

Key Words: Flora, range extensions, rare plants, vascular plants, Yukon Territory.

Since Hultén's *Flora of Alaska and Neighboring Territories* was published in 1968, many investigators have contributed additional knowledge of vascular plant ranges in the Yukon Territory. However, some areas have received less attention than others; e.g., some parts of southeastern Yukon (which I define here as that area of the Territory lying east of the Canol Road; see Figure 1). Although several authors have reported their finds from extreme southeastern Yukon and adjacent areas, much of the more northern portion has not yet been covered.

This paper deals mainly with the Frances Lake area, but also includes a few sites to the south and northwest of it. Since 1973, I have collected many species in this area which appear to be first collections from southeastern Yukon within the ranges predicted for them by Hultén (1968), or which constitute range extensions from sites adjacent to the nearest boundary lines on his maps. (The phrase "boundary lines" refers to Hultén's somewhat arbitrarily-drawn lines around the areas of a species' known occurences.) Also, some of the species are considered "rare" in Yukon by Douglas et al. (1981). (These authors define a rare plant as "one that has a small population within the area under consideration. It may be restricted to a small geographical area, where it may be locally common, or it may occur in low numbers over a wide area." They note that the application of this definition is "subjective".) I include here 72 species, 50 of which are range extensions, 12 are not range extensions but are considered rare, and 10 species are both range extensions and are considered rare.

Besides Hultén's *Flora*, I have drawn from Porsild and Cody (1980) for additional species locations in southeastern Yukon (although the authors did not intend their Yukon maps to be complete), as well as from other publications, which are cited where relevant. Thus, it is hoped that the information presented here reflects the current knowledge of these species' ranges in southeastern Yukon.

Collection Areas

Figure 1 shows the general locations of my collecting areas, and the abbreviations used for them in the text. Their co-ordinates and ecoregion designations (Oswald and Senyk 1977) follow:

FL (Frances Lake): 61°25'N, 129°30'W
(Liard River Ecoregion)
SL (Simpson Lake): 60°46'N, 129°13'W
(Liard River Ecoregion)
TC (Tom Creek): 60°17'N, 128°59'W
(Liard River Ecoregion)
WL (Watson Lake): 60°04' N, 128°40'W
(Liard River Ecoregion)
RR (Ross River): 61°52' N, 132°34'W
(Pelly Mountains Ecoregion)

The Frances Lake area, where most of the collections were made, is bordered on the east by the Logan Mountains and on the west by the Campbell Range. Glacial ice flowed southeastwards down the main valley during the last (Wisconsin) glaciation. Permafrost in the area is discontinuous and is most common on north-facing slopes, under thick accumulations of peat, and at higher elevations in the mountains. Frances Lake itself is a large, Y-shaped lake with a total length of approximately 50 km. Simpson Tower, a large, isolated, rounded mountain, lies between the two arms of the lake. The lake has several tributaries and is drained southward by the Frances River into

the Liard River. Glacio-fluvial, fluvial, and lacustrine deposits cover the lowlands. They are mostly well-forested but small bogs, fens and marshes are common. The surrounding uplands are covered with morainal deposits, much of which are drumlinized. Small glacio-fluvial and lacustrine deposits occur as well. The uplands are also forested, but small waterbodies, fens and bogs are common.

The forests of the Frances Lake area are dominated by White Spruce (*Picea glauca* (Moench) Voss), Black Spruce (*Picea mariana* (Mill.) Britt., Sterns & Pogg), Lodgepole Pine (*Pinus contorta* Dougl. ex Loud.), and Aspen (*Populus tremuloides* Michx.), alone or more commonly in various combinations. Other tree species present are Paper Birch (*Betula papyrifera* Marsh. ssp. *humilis* (Regel) Hult.), Balsam Poplar (*Populus balsamifera* L. ssp. *balsamifera*), Willows (*Salix* spp.), Tamarack (*Larix laricina* (Du Roi) K. Koch. var. *alaskensis* (Wight) Raup) (found along waterbodies and with Black Spruce in Sphagnum bogs), and Alpine Fir (*Abies lasiocarpa* (Hook.) Nutt.) (found scattered at higher elevations in the uplands and to tree-line in the mountains where it often forms extensive open stands).

Prominent shrubs commonly found in the forests and shrub communities include willows (*Salix* spp.), Alder (*Alnus crispa* (Ait.) Pursh), Shrub Birch (*Betula glandulosa* Michx.), Labrador Tea (*Ledum palustre* L.), and blueberry (*Vaccinium* spp.). Common dwarf shrubs include Low-Bush Cranberry (*Vaccinium vitis-idaea* L. ssp. *minus* (Lodd.) Hult.), Crowberry (*Empetrum nigrum* L. ssp. *hermaphroditum* (Lange) Bocher), and, on drier sites, Kinnikinnick (*Arctostaphylos uva-ursi* (L.) Spreng.).

Ground cover in the forests is dominated by lichens (especially *Cladina* spp. and *Cladonia* spp.) on the drier sites, by feathermosses (particularly *Hylocomium splendens* (Hedw.) B.S.G. and *Pleurozium schreberi* (Brid.) Mitt.) and other mosses on moister sites and in denser forests, or more commonly by a mixture of lichens and mosses. Grasses and forbs are minor components of the forest vegetation, but dominate much alpine tundra.

Bogs are dominated by open Black Spruce (often with Tamarack), ericaceous and other shrubs, and hummocks of Sphagnum mosses (*Sphagnum* spp.), and often cover large areas, especially in the uplands. Fens are common in poorly drained areas and are dominated by sedges (*Carex* spp.)

The Tom Creek (TC) collections were made from a large, densely-forested bedrock hill overlain by fluted moraine, from a White Spruce stand and an old logging area on the floodplain of Tom Creek at the base of the hill, and along the Campbell Highway and a Yukon Lands and Forests Service road which leads to the top of the hill. Species composition of the vegetation of this area is similar to that of the Frances Lake area.

The Watson Lake (WL) collection sites were all disturbed sites within the town limits, except for a small pond near town where the aquatic *Polygonum amphibium* was found.

Collections from Simpson Lake (SL) were made along the side of the Campbell Highway.

The collections from the Ross River (RR) area were all (with the exception of *Ranunculus cymbalaria*, which I found in a field within the townsite) made from alpine tundra and scree slopes on a steep mountain approximately 15 km south of the town.

Further information regarding geology, climate, vegetation, etc., of each area can be found in Oswald and Senyk (1977).

Annotated Species List

The specimens reported here have been deposited in one or more of the following herbaria: Royal British Columbia Museum, (formerly B.C. Provincial Museum) Victoria, B.C. (V); National Herbarium, Canadian Museum of Nature (formerly National Museum of Natural Sciences), Ottawa (CAN); Vascular Plant Herbarium, Agriculture Canada, Ottawa (DAO).

The collection numbers listed for each species are my own. In some instances, a specimen was given two different numbers when sent to both CAN and V; these are indicated by an equal sign and a note to avoid confusion. Taxonomy follows Hultén (1968) and Porsild and Cody (1980), with synonyms (used by the various other authors cited) following in parentheses.

POLYPODIACEAE

Gymnocarpium jessoense ssp. *parvulum* [*G. robertianum* sensu Hultén (1968); *Dryopteris robertiana* sensu Porsild and Cody (1980)], Nahanni Oak Fern.

FL: 517, 1118 (both DAO): in crevices of rock outcrops, 915 and 790 m elevation.

The Frances Lake area lies approximately 425 km southeast of the nearest locations shown for the species by Hultén (1968) in west central Yukon. Porsild and Cody (1980) also show locations in southwestern District of Mackenzie. The type of ssp. *parvulum* was collected below Virginia Falls in Nahanni National Park (W. J. Cody, personal communication). Listed in Douglas et al. (1981) as "rare".

Polypodium virginianum [*P. vulgare* ssp. *columbianum* sensu Hultén (1968)], Rock Polypody.

TC: 1041 (V, CAN, DAO): in crevices of rock outcrop, 900 m elevation.

Hultén (1968) calls this species *P. vulgare* ssp. *columbianum* but W. J. Cody (personal communication) says the correct name for all specimens from mid-British Columbia northward is *P. virginianum*. Hultén shows only a western Yukon range for this species, but Douglas et al. (1981) indicate that it has

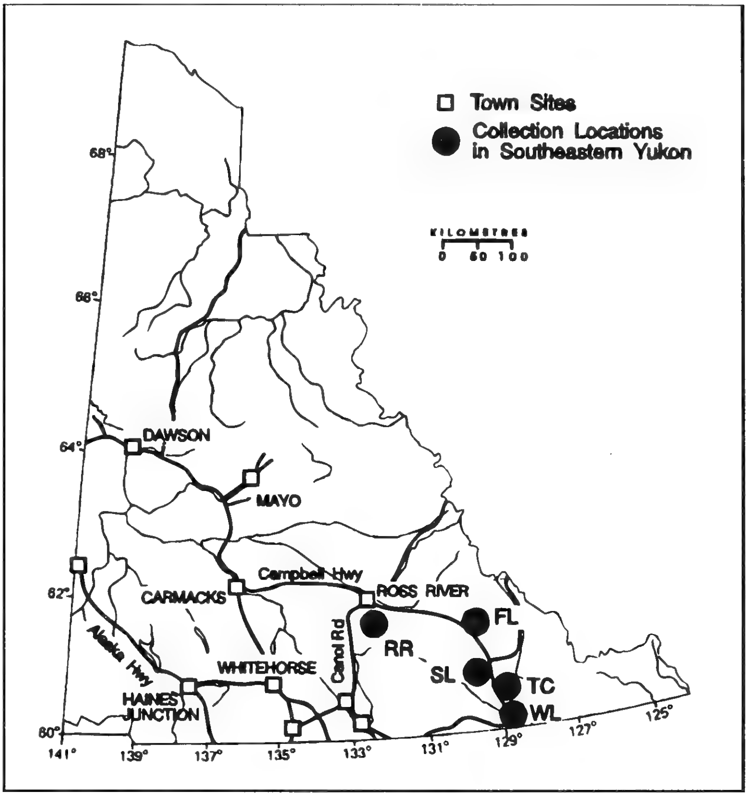

FIGURE 1. Map of Yukon Territory showing collecting areas (see text for details). Drafted by Marcel Jomphe.

been found in the Watson Lake area as well, and list it as "rare". Porsild and Cody (1980) show additional locations for the species in extreme southeastern Yukon. The Tom Creek location lies approximately 30 km north of Watson Lake.

EQUISETACEAE

Equisetum fluviatile, Water Horsetail.

FL: 1158, 1159, 1160, 1763 (all DAO): along cobbly lakeshore and in adjacent shallows, 890 m elevation.

The Frances Lake area lies approximately 200 km east of the nearest locations shown for the species by Hultén (1968) in south central Yukon, and approximately 175 km north of an indicated location at Watson Lake.

Equisetum sylvaticum, Wood Horsetail.

FL: 300 (V): in moist ground at edge of sedge meadow, 775 m elevation. 1163 (DAO): in dense Black Spruce/Feathermoss forest, 785 m elevation.

Hultén (1968) shows three separate areas for this species in Yukon and western District of Mackenzie. The Frances Lake collection helps fill the gap between them. Porsild and Cody (1980) also indicate several other stations in southeastern Yukon. Thus the areas delineated by Hultén can be merged into one to include the Frances Lake area.

LYCOPODIACEAE

Lycopodium complanatum, Flatbranch Club-moss.

FL: 238 (CAN) = 352 (V) (duplicates at CAN, V, DAO): in open Pine-Spruce woods, 920 m elevation.

The Frances Lake area lies approximately 200 km east of the nearest locations shown for this species in the Yukon by Hultén (1968), and this collection helps fill the gap between his Yukon and western District of Mackenzie ranges.

ISOËTACEAE

Isoëtes muricata var. *Braunii* (*I. echinospora*), Quillwort.

FL: 897 (V, CAN, DAO): in shallows of small upland lake, 890 m elevation.

This collection site lies within Hultén's (1968) Yukon range, but this is only the second report of the species from the Territory. Porsild (1951) found it in Sheldon Lake, 200 km northwest of Frances Lake collection site. Listed in Douglas et al. (1981) as "rare".

POTAMOGETONACEAE

Potamogeton alpinus ssp. *tenuifolius*, Northern Pondweed.

FL: 218 (V), 268 (CAN): in muddy bottom of shallow cove of Frances Lake, 775 m elevation.

The Frances Lake area lies approximately 200 km east of the nearest locations shown for this species in the Yukon by Hultén (1968).

Potamogeton praelongus, White-stemmed Pondweed.

FL: 1209 (V, CAN, DAO): in shallows of small upland lake, 890 m elevation.

Hultén shows only two collection locations for this species in Yukon, one in the extreme north and the other in the southwestern part of the Territory, approximately 500 km west of the Frances Lake area. The Frances Lake collection is only the third reported from the Territory. Porsild and Cody (1980) show it as also occurring in extreme southwestern District of Mackenzie near the Yukon border. Listed in Douglas et al. (1981) as "rare".

SCHEUCHZERIACEAE

Triglochin palustre, Marsh Arrowgrass.

FL: 212 (CAN) = 340 (V): growing in a garden on soil transported from marshy edge of Frances Lake, 778 m elevation.

The Frances Lake collection site lies approximately 150 km north and about as far southeast of the nearest locations for this species shown in Hultén (1968). He also indicates a western District of Mackenzie range. As well, Porsild and Cody (1980) show additional locations for the species in extreme southeastern Yukon.

GRAMINEAE

Bromus ciliatus, Fringed Brome.

TC: 1409 (DAO): abundant in a meadow in an old logging area along Tom Creek, 740 m elevation.

This collection site lies within Hultén's (1968) Yukon range, but the species is listed in Douglas et al. (1981) as "rare".

Hordeum jubatum, Foxtail Barley.

FL: 169 (V): in disturbed area around cabin, 778 m elevation.

Hultén (1968) shows this species as occurring in southwestern and southern Yukon and also in western District of Mackenzie. The Frances Lake area lies approximately 200 km east of the nearest indicated site. This species is weedy and is common along roadsides and in disturbed sites.

CYPERACEAE, sedges

Carex arcta.

FL: 119 (CAN) = 288 (V) (duplicates at CAN, V, DAO): along sandy beach of Frances Lake, 775 m elevation.

This collection site lies within Hultén's (1968) Yukon range, but the species is listed as "rare" in Douglas et al. (1981), who only show three localities along the Canol Road.

Carex interior.

FL: 1493 (DAO): in dense White Spruce/ Feathermoss forest near Frances Lake, 775 m elevation.

The Frances Lake collection site lies approximately 130 km north of Hultén's (1968) sole indicated Yukon location near Watson Lake. Listed in Douglas et al. (1981) as "rare".

Carex loliacea.

FL: 1471 (DAO): along shore of pond, 780 m elevation; 1472 (V): in dense willow thicket in sluggish upland drainageway, 900 m elevation.

Hultén (1968) shows only a few locations for this species in the Yukon along the western border, in the south central part of the Territory, and in the Watson Lake area. He also indicates a southwestern District of Mackenzie range for the species. The Frances Lake area lies roughly halfway between his Yukon and Mackenzie ranges.

Carex phaeocephala.

FL: 78 (V, DAO): in subalpine meadow, 1220 m elevation.

Hultén (1968) shows only three Yukon locations for this species, all along the southern border. The Frances Lake area lies approximately 275 km northeast of the nearest indicated site, and roughly halfway between that and a location in western District of Mackenzie. Listed in Douglas et al. (1981) as "rare".

Carex tenuiflora.

FL: 1469 (DAO): in open Spruce-Tamarack bog, 930 m elevation.

The Frances Lake collection site lies approximately 160 km southeast of Hultén's (1968) nearest indicated Yukon location for this species. As well, Porsild and Cody (1980) show locations in southwestern District of Mackenzie.

LILIACEAE

Allium schoenoprasum var. *sibiricum*, Chive.

FL: 226 (CAN, DAO) = 159 (V) (duplicates at V, CAN, DAO), 1178 (DAO): along sandy and gravelly beaches of Frances Lake, 775 m elevation.

Hultén (1968) shows locations for this species in southern Yukon as far east as Watson Lake, and northwestward from there. The Frances Lake collection area lies approximately 200 km east of the nearest indicated site in south central Yukon, and approximately 150 km north of Watson Lake. As well, Porsild and Cody (1980) show additional locations for the species in southeastern Yukon east of Frances Lake, thus helping to fill in the gap between Hultén's Yukon and western District of Mackenzie ranges.

Smilacina stellata, False Solomon's Seal.

FL: 1179 (DAO): along sandy shore of pond, 778 m elevation.

Hultén (1968) shows locations for this species in the Watson Lake area and in south central and

southwestern Yukon. He also shows a southwestern District of Mackenzie range for this species. The Frances Lake collection site lies approximately 150 km north of the nearest indicated site in southern Yukon,and helps fill the gap between the species' Yukon and Mackenzie ranges.

Smilacina trifolia, Three-leaved Solomon's Seal.

FL: 565 (CAN, DAO): at edge of mossy bog, 850 m elevation.

Hultén (1968) shows this species' range as just reaching into the Yukon, east of Watson Lake, from northeastern British Columbia, but shows no Yukon locations. Porsild and Cody (1980), however, show locations in extreme southeastern Yukon, and Douglas et al. (1981) indicate a site approximately 125 km west of Watson Lake. Thus, the Frances Lake collection extends the species' known Yukon range approximately 150 km northward. Listed in Douglas et al. (1981) as "rare".

ORCHIDACEAE

Amerorchis rotundifolia (*Orchis rotundifolia*), Round-leaved Orchis.

FL: 566 (CAN), 1190 (DAO): in open Black Spruce-Tamarack bog, 890 m elevation.

Hultén (1968) shows this species as occurring near Watson Lake as well as other locations in south central and western Yukon. Porsild and Cody (1980) show collection sites southeast of Frances Lake area as well. The Frances Lake collection site lies approximately 125 km north of Watson Lake.

Calypso bulbosa, Fairy Slipper.

FL: 1779 (DAO): under open Aspen and Spruce near lakeshore, 780 m elevation.

Hultén (1968) shows only a few Yukon locations for this species, all but one lying along the southern border. The Frances Lake collection area lies approximately 150 km north of the nearest indicated site near Watson Lake. The species appears to be very scarce in the Frances Lake area.

Listera cordata, Heart-leaved Twayblade.

TC: 1036 (V, CAN, DAO): in moist dense Spruce-Birch forest, 900 m elevation.

The Tom Creek area lies within Hultén's (1968) Yukon range, and is approximately 30 km north of an indicated location at Watson Lake. Listed in Douglas et al. (1981) as "rare".

SALICACEAE, willows.

Salix pyrifolia.

TC: 1355 (DAO): along roadside, 900 m elevation.

Hultén (1968) does not include this species in his *Flora*, but his *Supplement* (1973) cited Argus' (1973) report of its occurrence at Palmer Lake in northern Yukon. Brayshaw (1976) shows several locations in northern British Columbia near the Yukon border, and Porsild and Cody (1980) indicate its occurrence in southwestern District of Mackenzie. Thus the Tom Creek collection constitutes a slight extension northward and westward of this species' main range, and is apparently only the second reported from the Yukon. Listed in Douglas et al. (1981) as "rare".

Salix Scouleriana.

FL: 1294, 1342, 1348 (all DAO), 1345 (CAN, DAO): common in thickets and forests in the Frances Lake area.

Hultén (1968) shows two separate ranges for this species in the Yukon, one in the west central part and the other in the southern part and along the Canol Road. The Frances Lake area lies approximately 175 km east and approximately the same distance north of Hultén's nearest indicated sites. He also shows a western District of Mackenzie range for the species. The Frances Lake collections help fill the gap between these areas.

MYRICACEAE

Myrica gale, Sweet Gale.

FL: 174 (V, DAO), 240 (CAN, DAO): common along shore of Frances Lake, 775 m elevation.

Hultén (1968) shows only a few locations for this species in the Yukon, all in the west central part. The Frances Lake area lies approximately 400 km southeast of the nearest indicated location. Porsild and Cody (1980) show the species as also occurring in southwestern District of Mackenzie.

POLYGONACEAE

Polygonum amphibium ssp. *laevimarginatum* (*P. amphibium* var. *stipulaceum*), Water Smartweed.

WL: 893 (V, CAN, DAO): in small pond near town, 680 m elevation.

Hultén (1968) shows locations for this species in central, western, and south central Yukon. As well, Scotter and Cody (1979) reported it from Coal River Springs in southeastern Yukon. The Watson Lake collection site lies roughly halfway between these areas.

CHENOPODIACEAE

Chenopodium capitatum, Strawberry-blite.

FL: 42 (CAN), 213 (V): in disturbed ground around cabins, 778 m elevation.

Hultén (1968) shows a number of locations for this species in the southern half of the Yukon. The Frances Lake area lies approximately 200 km east of the nearest indicated sites in the south central part of the Territory, and approximately 175 km northeast of a location west of Watson Lake. It is a native species, but often weedy.

CARYOPHYLLACEAE

Spergularia rubra, Purple Sand-spurry.

TC: 919 (V, CAN, DAO): on packed dirt road, 915 m elevation.

Hultén (1968) shows no Yukon locations for this species, the nearest being in extreme northwestern British Columbia. However, Porsild (1974) found it in the Mayo area, where it was then "well-established". The Tom Creek collection is thus only the second reported from the Yukon, but it is an introduced weed and is probably present in many other disturbed sites throughout the Territory.

RANUNCULACEAE

Ranunculus confervoides (*R. aquatilis* var. *eradicatus*), Water Crowfoot.

FL: 226 (V, DAO): at edge of shallow cove of Frances Lake, 775 m elevation; 301 (CAN): on muddy beach, 775 m elevation.

Hultén (1968) shows only four locations for this species in the Yukon, all in the south central and southwestern parts. As well, Porsild and Cody (1980) show it as occurring in southwestern District of Mackenzie. The Frances Lake area lies approximately 200 km east of Hultén's nearest indicated site and helps fill the gap between the species' Yukon and Mackenzie ranges.

Ranunculus cymbalaria, Northern Seaside Buttercup.

RR: 1656 (DAO), 1784 (DAO): in moist weedy field along roadside, 730 m elevation.

Hultén's (1968) map shows a number of separate, delineated areas for this species in the North, including southern Yukon north to the Dawson area. He notes that it is "sometimes apparently spread by human activity." This is likely the case with the Ross River occurrence, which lies 200 km northeast of Whitehorse, the nearest indicated location.

Ranunculus Gmelini ssp. *Gmelini*, Gmelin Buttercup.

FL: 303 (CAN, DAO): in garden, on soil transported from nearby clayey cove bottom of lake, 778 m elevation.

Hultén (1968) shows Yukon locations for this species in the far north, west central, and south central parts of the Territory. The Frances Lake area lies approximately 200 km east and northeast of the nearest indicated sites.

Ranunculus trichophyllus (*R. aquatilis* var. *capillaceus; R. aquatilis* var. *subrigidus*), Water Crowfoot.

FL: 215, 220 (both V), 308 (CAN), 1225 (DAO): in shallow cove of Frances Lake, 775 m elevation; 901 (V, CAN): in shallows along shore of small upland lake, 890 m elevation.

These sites lie within Hultén's (1968) Yukon range, but are the only reported collections from southeastern Yukon. Listed in Douglas et al. (1981) as "rare".

FUMARIACEAE

Corydalis aurea, Golden Corydalis.

FL: 1766 (DAO): in disturbed ground around cabins, 775 m elevation.

The Frances Lake collection site lies halfway between Yukon locations shown for the species by Hultén (1968) at Ross River and Watson Lake, and helps fill the gap between his indicated Yukon and western District of Mackenzie ranges. It appears to be scarce in the Frances Lake area.

Corydalis sempervirens, Pink Corydalis.

FL: 1765 (DAO): in disturbed ground around cabins, 890 m elevation.

The Frances Lake area lies approximately 200 km east of Hultén's (1968) nearest indicated locations for this species in southern Yukon, and about the same distance north of a site west of Watson Lake. It occurs occasionally in disturbed sites and recent burns.

CRUCIFERAE

Capsella bursa-pastoris, Shepherd's Purse.

FL: 88 (CAN, DAO): along roadside, 780 m elevation.

Hultén (1968) shows only a few locations in the Yukon for this species. The Frances Lake area lies approximately 225 km northeast of the nearest indicated site and is apparently only the first reported collection from southeastern Yukon. However, it is an introduced weed and is probably present in many other disturbed sites throughout the Territory.

Cardamine pensylvanica, Bitter Cress.

FL: 272 (V, DAO): on sandy beach of Frances Lake, 775 m elevation.

This collection site lies within Hultén's (1968) Yukon range, but the species is listed as "rare" in Douglas et al. (1981), and this is only the fifth locality yet known for the Yukon Territory.

Draba alpina (det. G. A. Mulligan), Alpine Rockcress.

FL: 1273 (DAO): in moist alpine meadow, 1630 m elevation.

Hultén (1968) shows only three widely separated locations for this species in the Yukon. The Frances Lake collection area lies more than 400 km southeast of an isolated circumscribed locality in central Yukon. The species has also been found in western District of Mackenzie by Porsild and Cody (1980).

Draba borealis (det. G.A. Mulligan), Northern Rockcress.

FL: 536, 537 (both DAO): from moist alpine sites, 1640 and 1580 m elevation; RR: 1574 (DAO): in moist shrubby alpine meadow, 1385 m elevation.

Hultén (1968) shows only one location for this species in the Yukon, in the southwest. However, Nagy et al. (1979) found it in northern Yukon, and Porsild (1974) reported it from the Dempster Highway and Mayo areas, and noted that it was "otherwise known from half a dozen stations in the southern part". As well, Porsild and Cody (1980) show several locations in District of Mackenzie (east

and north of Frances Lake area), and several in northern British Columbia. Thus, this species' Yukon range encompasses much, if not all, of the Territory.

Draba fladnizensis.
RR: 1582 (DAO): in *Cassiope tetragona* heath on steep mountain slope, 1525 m elevation; 1587 (DAO): on coarse scree slope, 1550 m elevation.

Hultén (1968) shows only two locations in Yukon for this species, one in the Mayo area and one north of Dawson. Porsild and Cody (1980) show additional locations in southwestern Yukon, in northeastern British Columbia near the Yukon border, in northern Yukon, and in southwestern District of Mackenzie. The Ross River collection helps bridge the gap between these sites, and indicates that this species' range probably includes most of the Yukon Territory where suitable habitats exist.

Eutrema Edwardsii.
FL: 95 (CAN) = 275 (V) (duplicates at CAN, V, DAO): in moist ground along alpine brook, Simpson Tower, 1500 m elevation.

Hultén (1968) shows this species as occurring in southwestern Yukon, in the extreme north, and in western District of Mackenzie. The Frances Lake collection area lies more than 200 km south of the nearest indicated site in western Mackenzie.

Subularia aquatica ssp. *americana*, Awlwort.
FL: 101 (CAN) = 223 (V), 1274 (DAO): on muddy bottom of shallow cove of Frances Lake, 775 m elevation.

This collection site lies within Hultén's (1968) Yukon range, but the species is listed in Douglas et al. (1981) as "rare" (only three localities were previously known in the Yukon Territory).

Thlaspi arvense, Pennycress.
FL: 102 (CAN) = 147 (V): in disturbed area around corral, 778 m elevation.

Hultén (1968) shows only two locations in Yukon for this species, both in the south central part of the Territory. The Frances Lake area lies approximately 225 km northeast of the nearest indicated site. It is an introduced weed, and is probably present in other disturbed sites outside his indicated range.

SAXIFRAGACEAE

Mitella nuda, Mitrewort.
FL: 184 (V): in wet Sphagnum moss at pond edge, 800 m elevation; 365 (CAN, DAO), 1237 (DAO): in dense Spruce/Feathermoss forest, 775 and 780 m elevation.

These collection sites lie on the northern border of Hultén's (1968) Yukon range, approximately 170 km north of an indicated site near Watson Lake. Listed in Douglas et al. (1981) as "rare".

Mitella pentandra, Alpine Mitrewort.
FL: 366 (CAN) = 403 (V): in Sub-alpine Fir-Spruce forest near treeline, 1500 m elevation.

This collection site lies within Hultén's (1968) Yukon range, but the species is listed in Douglas et al. (1981) as "rare". It was previously known from only three localities in the Yukon Territory.

ROSACEAE

Potentilla villosa, Villous Cinquefoil.
FL: 329 (CAN) = 387 (V) (duplicates at CAN, V, DAO), 331 (CAN), 388 (V): on stony alpine tundra, 1530 m elevation.

The Frances Lake area lies approximately 190 km eastward of Hultén's (1968) nearest indicated locations in south central Yukon. He states that it is "rare inland". Douglas and Douglas (1978) reported it from Kluane National Park, so the Frances Lake collection is apparently only the fourth reported from the Yukon.

LEGUMINOSAE

Melilotus alba, White Sweet Clover.
WL: 220 (CAN) = 342 (V) (duplicates at V, CAN, DAO), 993 (DAO): along roadside, 680 m elevation.

According to Hultén's (1968) map, the Watson Lake collections constitute the third reported location for this species in Yukon, the nearest other lying approximately 240 km to the west. However, the species is an introduced weed and is probably present in many other disturbed areas throughout the Yukon.

Melilotus officinalis, Yellow Sweet Clover.
WL: 994 (DAO): along gravelly roadside, 680 m elevation.

According to Hultén's (1968) map, this would be the fourth reported station for the species in the Territory, the nearest other lying approximately 240 km to the west. However, it is an introduced weed and is probably present in many other disturbed sites throughout the Territory.

VIOLACEAE

Viola renifolia var. *Brainerdii*, White Violet.
FL: 1258 (DAO): in closed Aspen woods in uplands, 895 m elevation; 1259 (DAO): in willow thicket in upland drainageway, 900 m elevation.

Hultén (1968) shows the Yukon range for this species as reaching into only the southern part of the Territory. However, Porsild (1951) reported it from Mt. Sheldon on the Canol Road, approximately 200 km northwest of the Frances Lake collection sites. Porsild and Cody (1980) also show dots in the Mt. Sheldon area. Hence, Hultén's (1968) Yukon boundary line for this species can be extended northward at least 250 km.

ONAGRACEAE

Epilobium adenocaulon (*E. glandulosum* var. *adenocaulon; E. ciliatum* ssp. *glandulosum*), Northern Willow-herb.

FL: 1182 (DAO): in open Black Spruce-Tamarack woods, 890 m elevation.

This collection site lies just on the northern border of Hultén's (1968) southeastern Yukon range. Listed in Douglas et al. (1981) as "rare".

UMBELLIFERAE

Cicuta bulbifera, Water Hemlock.

FL: 392 (CAN) = 419 (V), 1256 (DAO): abundant along cobbly shore of small upland lake, 890 m elevation.

Hultén (1968) shows no Yukon locations for this species, the nearest being Norman Wells in western District of Mackenzie. However, Porsild (1974) reported it from northeast of Mayo, and it was then "new to the Yukon". The map in Douglas et al. (1981) shows a circle in the Watson Lake area, indicating a literature record for the species there. Thus the Frances Lake collection is only the third reported location for the species in the Territory. Listed in Douglas et al. (1981) as "rare".

CORNACEAE

Cornus stolonifera, Red-osier Dogwood.

FL: 1149 (V, DAO): on sandy-gravelly spit, Frances Lake, 775 m elevation.

This collection helps fill the small gap between the south central and eastern lobes of Hultén's (1968) Yukon range. I have encountered this species only once in the Frances Lake area.

PYROLACEAE

Pyrola chlorantha, Wintergreen.

FL: 190 (V, DAO), 284 (CAN, DAO): in moist Spruce forests, 790 m elevation.

The Frances Lake area lies halfway between Hultén's (1968) locations for this species near Ross River and Watson Lake, and lies approximately 200 km east of indicated sites in central Yukon. He also shows a western District of Mackenzie range.

ERICACEAE

Arctostaphylos alpina, Alpine Bearberry.

FL: 143 (CAN), 1167 (DAO): in dry alpine heath, 1620 and 1680 m elevation.

The Frances Lake area lies approximately 200 km east of Hultén's (1968) nearest indicated locations for this species in the Yukon.

Chamaedaphne calyculata (*Cassandra calyculata*), Leatherleaf.

FL: 551 (V, CAN, DAO): at edge of small bog pond, 780 m elevation.

Hultén (1968) shows four central Yukon locations for this species and a circumscribed location in the Watson Lake area. The Frances Lake area lies roughly halfway between the Watson Lake site and an indicated location at Ross River.

Phyllodoce glanduliflora (*P. aleutica* ssp. *glanduliflora*), Yellow Mountain-heather.

FL: 154 (CAN) = 311 (V) (duplicates at CAN, V, DAO): in stony dry soil on mountain summit, 1530 m elevation; 1169 (DAO): on dry alpine tundra, 1530 m elevation.

Hultén (1968) shows only two locations in Yukon for this species, one south of the Cantung area near the Yukon-Northwest Territories border, and the other in southwestern Yukon on the British Columbia border. Porsild and Cody (1980) show additional locations in southwestern Yukon in the Kluane area. The Frances Lake collections thus extend Hultén's (1968) eastern Yukon boundary line approximately 75 km southwest. Listed in Douglas et al. (1981) as "rare".

Vaccinium ovalifolium, Early Blueberry.

FL: 157 (CAN), 554 (CAN), 192 (V), 1170 (DAO): small shrub in open subalpine forests, 1350 to 1500 m elevation.

Hultén (1968) shows no Yukon locations for this species, the nearest shown being in northwestern British Columbia, approximately 400 km southwest of the Frances Lake area. However, Douglas et al. (1981) show collection locations in Kluane National Park and Carcross, as well as at Frances Lake, and list the species as "rare".

PRIMULACEAE

Primula egaliksensis, Greenland Primrose.

FL: 182 (V) = 281 (CAN): on muddy beach of Frances Lake, 775 m elevation; 1280 (DAO): on willow/sedge flat, Frances Lake, 775 m elevation.

Hultén (1968) shows only a few locations for this species in southern Yukon. The Frances Lake area lies approximately 200 km eastward of the nearest indicated site.

Trientalis europaea ssp. *arctica*, Arctic Starflower.

FL: 1783 (V, DAO): in moist moss under willows, 890 m elevation.

Hultén (1968) shows a few locations for this species in the south, central, and western parts of the Territory. The Frances Lake area lies approximately 200 km east, and about as far south, of the nearest indicated locations.

POLEMONIACEAE

Collomia linearis.

WL: 598 (V, CAN), 1038 "A" (DAO): in disturbed gravelly area, 685 m elevation.

Hultén (1968) considered this species an introduced weed, and indicated only three circumscribed collection sites for it, in central and southern Yukon more than 350 km from Watson Lake. Scotter and Cody (1979), however, found it in extreme southeastern Yukon near Larsen Creek Hot Springs, but were doubtful that it had been introduced there. The collections reported here, however, are likely anthropochorus.

OROBANCHACEAE

Boschniakia rossica, Ground-cone.

FL: 212 (V) = 251 (CAN), 1201 (DAO), 1202 (DAO): in closed Spruce/Alder/Feathermoss forest, 775-900 m elevation.

The Frances Lake area lies approximately 200 km southeast of Hultén's (1968) nearest indicated locations for this species. As well, Porsild and Cody (1980) show a location in the Watson Lake area. These collections help fill the gap between the two lobes of Hultén's southern Yukon range.

PLANTAGINACEAE

Plantago major var. *major*, Common Plantain.

FL: 259 (CAN) = 360 (V) (duplicates at V, CAN, DAO): in gravel pit along road, 790 m elevation.

Hultén (1968) shows only a few Yukon locations for this species, most of them in the southern part of the Territory. The Frances Lake area lies approximately 200 km northeast of the nearest indicated site, and the collection is the first reported from southeastern Yukon. However, it is an introduced weed and probably present in many other disturbed sites throughout the Yukon.

COMPOSITAE

Achillea lanulosa (*A. millefolium* var. *lanulosa*), Yarrow.

FL: 1130 (DAO): in small meadow along Frances River, 775 m elevation.

Hultén (1968) shows only two locations in the Yukon for this species, both in the west central part. The Frances Lake collection thus is apparently the first reported from southeastern Yukon. Listed in Douglas et al. (1981) as "rare".

Achillea sibirica, Siberian Yarrow.

FL: 45 (CAN), 131 (V): in grassy disturbed area around cabins, 780 m elevation; 1131 (DAO): along gravelly-sandy beach of Frances Lake, 775 m elevation.

Hultén (1968) shows only four locations for this species in the Yukon, all in the west central part more than 450 km west of the Frances Lake area. As well, Porsild and Cody (1980) show locations for the species in extreme southeastern Yukon and in western District of Mackenzie.

Antennaria neglecta ssp. *Howellii* (*A. Howellii*), Everlasting.

TC: 921 (V, CAN, DAO): on packed disturbed ground around buildings, 915 m elevation.

This collection site lies within Hultén's (1968) Yukon range, and is approximately 30 km north of the nearest indicated station, in the Watson Lake area. Listed in Douglas et al. (1981) as "rare".

Antennaria stolonifera, Everlasting.

FL: 523 (DAO): in moist alpine meadow, 1600 m elevation.

Hultén (1968) shows locations for this species near Mayo and along the Canol Road. The Frances Lake area lies approximately 200 km east of the nearest indicated sites.

Cirsium foliosum, Leafy Thistle.

FL: 1265 "A" (DAO): in small meadow along Frances River, 775 m elevation.

Hultén (1968) shows only four locations for this species in the Yukon, one in the southwest and the others in south central and central Yukon. The Frances Lake area lies approximately 200 km east of the nearest indicated site. According to Hultén's map, this is only the fifth reported collection of this species from the Territory. It appears to be scarce in the Frances Lake area.

Crepis elegans, Elegant Hawk's-beard.

FL: 62 (CAN) = 257 (V) (duplicates at CAN, V, DAO): in gravel pit near road, 780 m elevation. SL: 1265 "B" (DAO): along roadside, 760 m elevation.

Hultén (1968) shows a number of locations for this species in the Yukon, from the south central part northwest to the Dawson area. The Frances Lake area lies approximately 200 km northeast of the nearest indicated site, and the Simpson Lake area lies about the same distance east of it. These two sites are apparently the first and second reported locations for the species in southeastern Yukon, but it is a weedy species and is probably present in other disturbed sites in the area.

Crepis tectorum, Hawk's-beard.

WL: 595 (V, CAN), 991 (DAO): in disturbed gravelly areas around town, 680 m elevation.

Hultén (1968) shows only one Yukon site for this species, in the southwestern (Kluane) area, and does not indicate a possible Yukon range. However, since the species is an introduced weed, it is probably present in many disturbed sites throughout the Territory.

Senecio congestus, Marsh Fleabane.

FL: 529 (CAN, DAO): along marshy shore of small upland lake, 890 m elevation.

The Frances Lake collection site lies approximately 200 km east of Hultén's (1968) nearest indicated site for this species, and lies roughly halfway between his Yukon and western District of Mackenie ranges. It appears to be scarce in the Frances Lake area.

Solidago multiradiata var. *multiradiata*, Northern Goldenrod.

FL: 86 (V, DAO): in subalpine meadow, 1220 m elevation. SL: 1270 (DAO): along roadside, 760 m elevation.

Hultén (1968) shows this species as occurring throughout most of the Yukon as well as in District of Mackenzie. The Frances Lake and Simpson Lake

areas lie approximately 175 km east of the nearest indicated sites in south central Yukon, and these collections thus help fill the gap between the species' Yukon and District of Mackenzie ranges.

Taraxacum officinale, Common Dandelion.

FL: 81 (CAN) = 267 (V) (duplicates at CAN, V, DAO): in disturbed area near shore of Frances Lake, 775 m elevation; 400 (CAN): in disturbed ground around cabin, 778 m elevation; TC: 1016 (DAO): along roadside, 765 m elevation.

Hultén (1968) shows only three locations in the Yukon for this species. Both the Frances Lake and Tom Creek collection areas lie approximately 200 km east of his nearest indicated sites. The species is an introduced weed and is probably present in many other disturbed sites throughout the Territory.

Tripleurospermum inodorum (*Matricaria maritima* var. *agrestis*), Wild Chamomile.

FL: 211 (V, DAO): in disturbed ground around cabins, 778 m elevation.

Hultén (1968) shows no Yukon collection sites for this species, the nearest locations being in central Alaska, nor does he indicate a probable Yukon range for the species. However, since it is an introduced weed, it is probably present in many other disturbed sites throughout the Territory.

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Food and Habitat Used by Grizzly Bears, *Ursus arctos*, along the Continental Divide in Waterton Lakes National Park, Alberta

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Grizzly Bear (*Ursus arctos*) food and habitat use was studied in Waterton Lakes National Park during 1981-1983 using field observation, fecal analysis, and radiotracking. During spring and autumn the Grizzly Bears' main food was roots of Yellow Hedysarum (*Hedysarum sulphurescens*). During June through early August, Glacier Lily (*Erythronium grandiflorum*) corms and green vegetation (mainly Cow Parsnip (*Heracleum lanatum*) and other umbellifers) dominated the diet. *Vaccinium* spp. fruits ripened during late July and August and became an important food at that time. Minor use of animal matter was recorded. Most Yellow Hedysarum diggings were recorded on steep, dry, sparse meadows facing south through west. Colluvial soil and exposure into desiccating chinook wind characterized these digging sites. In contrast, most Glacier Lily and green vegetation feeding sites were on moist east-facing avalanche slopes supporting alder (*Alnus viridis*) thickets and tall-herb meadow communities. *Vaccinium* feeding habitat varied from relatively xeric, chinook- and/or wildlife-influenced slopes to forest understory and mesic avalanche slopes. These results are compared with the feeding ecology of Grizzly Bears from a more xeric portion of the Front Ranges.

Key Words: Grizzly Bear, *Ursus arctos*, Food habits, Cow Parsnip, *Heracleum lanatum*, Glacier Lily, *Erythronium grandiflorum*, habitat use, *Hedysarum sulphurescens*, umbellifers, *Vaccinium*, Waterton Lakes National Park, Alberta

The Grizzly (Brown) Bear (*Ursus arctos*) is an omnivore that exploits ephemerally abundant, nutrient-rich food sources (Hamer 1985:194). This feeding strategy means that food and habitat used by bears often varies greatly between regions. Even the major foods eaten by Grizzly Bears from two neighbouring populations may differ (Mace and Jonkel 1986). In order to provide resource managers with locally pertinent information, we studied Grizzly Bears in the western and southwestern portions of Waterton Lakes National Park as part of a cooperative program of Grizzly Bear research between the University of Calgary and the Canadian Parks Service (formerly Parks Canada; Hamer et al. 1985). We report here food and habitat use.

Description of the Study Area

The study area occupied approximately 225 km^2 in the Front Ranges of the Rocky Mountains in the southwest-most corner of Alberta. The continental divide formed the western boundary of both our study area and Waterton Lakes National Park. The study area included the Cameron, Blakiston and Bauerman watersheds, and also approximately 2 km^2 of Glacier National Park, Montana, which lies immediately south of Waterton Lakes. Elevations in the study area range from 1300 to 2900 m. Diverse habitat types occur over small horizontal distances due to the numerous major and tributary drainages that dissect the area.

Precipitation in Waterton Lakes exhibits a distinct east-west gradient. Annual precipitation on the continental divide at Akamina Pass is about 1500 mm, but less than 750 mm falls in grasslands along the eastern boundary of the park (Poliquin 1973). The park is strongly influenced by Pacific air masses, especially chinook (foehn) wind. These strong, warm, westerly winds produce xeric conditions on exposed slopes and kill or stunt trees in exposed sites through red-belt injury to exposed foliage (Robins and Susut 1974).

The vegetation of the park was described by Kuchar (1973). The montane and subalpine zones of the study area are dominated by forest, but numerous forest openings occur. Some dry meadow or parkland (conifer savanna) openings may have been created by wildfire. Postfire forest re-establishment on exposed slopes subsequently may be inhibited by the xeric conditions that result from exposure to chinook wind and other factors. Avalanches maintain other shrub and meadow communities below treeline. Mesic avalanche paths usually have a dense, 2 to 4 m tall layer of alder. Tall-forb meadows occur between alder thickets on some mesic avalanche paths. Colluvium, including scree and talus, occurs commonly on moderate slopes and at the bases of steep slopes. The alpine zone begins at about 2100 m. Alpine communities range from moist forb meadows to Dryas (*Dryas octopetala*) tundra.

Methods

Grizzly Bear food and habitat use was determined during 1981-1983 by examining Grizzly Bear feeding sites, analyzing feces, and opportunistically

observing foraging bears with 20x–45x telescopes during daylight hours. We attempted to observe from >500 m to reduce disturbance. Two adult female Grizzly Bears were radiotracked from the ground using methods described by Hamer and Herrero (1987a).

Feeding sites usually were described where Grizzly Bears had been seen or radio-located. Cross-country searches for feeding activity (e.g., transects; Hamer and Herrero 1987a) had limited use due to difficult travelling conditions. In the few sites found while travelling cross-country, tracks were used to distinguish Grizzly and Black Bear (*Ursus americanus*) signs (Herrero 1985:189). In addition, all root and corm diggings were attributed to Grizzly Bears. Black Bears rarely dig for food (Herrero 1985:166). Hedysarum digging observations (sightings and field signs) were combined into "digging records" as described by Hamer and Herrero (1987a: 205).

Most feces were collected when associated with Grizzly Bear sightings or radio-locations. Other feces were judged to be from Grizzly Bears when they were associated with Grizzly Bear tracks (5 feces) or diggings (1), or when they exceeded one litre in volume (2) or contained roots (3). In the laboratory, five 10-mL sub-samples were removed from each fecal sample and examined, in 5-mL portions, under 7–40 power magnification using methods described by Hamer and Herrero (1987a). These methods result in minimum/maximum estimates of food item volume.

Approximately one-half of our food-habits data were derived from the two radio-equipped bears: at least 50% and as many as 68% of the 119 feces analyzed for food content and 53% (107/201) of the sightings of foraging Grizzly Bears were of these two individuals.

Food Habits

Yellow Hedysarum roots dominated the early and late season feces (Figure 1). Roots were either absent or less than one percent of fecal volume during early July-early September. A similar pattern was observed for foraging Grizzly Bears: less than 2 percent (116/6298) of our hedysarum digging records were recorded during 16 June – 15 September. Bearberries (*Arctostaphylos uva-ursi*) were a minor spring and autumn food according to fecal analysis (Figure 1) and feeding observations [all Bearberry feeding was observed during 1 May – 15 June (252 minutes) and 1 October – 15 November (304 minutes)].

Glacier Lily corms and green forage entered the diet as the spring growing season progressed. Umbellifers and graminoids (grasses, sedges, and rushes) were green-forage components of fecal samples through early October. Umbellifers composed most of the mid-summer fecal volume. This included recognizable fragments of Yellow Angelica (*Angelica dawsonii*), Cow Parsnip, and Sweet Cicely (*Osmorhiza occidentalis*), plus an "unidentified umbellifer" component. The latter was stem and petiole that likely was mainly Cow Parsnip: 77% (1150/1499) of the cropped umbellifer plants recorded during feeding site examinations were Cow Parsnip. Use of two other umbellifers was recorded during field observations: White Angelica (*Anglica arguta*)(less than 3% of classified umbellifer feeding) and Prairie Parsley (*Lomatium dissectum*) (only 3 cropped plants observed). Foraging Grizzly Bears characteristically selected the stems, petioles, and blossoms, but discarded the leaves, when feeding on Cow Parsnip, White Angelica, Prairie Parsley, and occasionally Sweet Cicely.

Glacier Lily corms composed 1–15% of fecal volume during early June through early August, but may have been under-represented in feces. On seven occasions, Grizzly Bears were observed digging corms essentially without interruption for 60–90 minutes. Yet corms composed <30% of the volume of all but one fecal sample collected from these sites. Either feeding effort associated with these small corms resulted in relatively little food per unit of time, or corms were significantly more digestible than other forage.

By early August, Grizzly Bears began to eat *Vaccinium* fruits. *Vaccinium* feeding continued into late October of 1981 but was not recorded after the end of September in 1982 and 1983. Bears also ate fruits of Buffaloberry (*Shepherdia canadensis*), Saskatoon (*Amelanchier alnifolia*), Prickly Currant (*Ribes lacustre*), and Mountain Ash (*Sorbus* spp.) in late summer and early autumn; only Saskatoon exceeded 2% of fecal volume for any semi-monthly period (10%, late September). Fruits may have been under-represented in feces because of their digestibility (Hatler 1972).

Ants occurred in 7 of the 119 feces analyzed (maximum frequency of occurrence, 27%, in early August). Fish occurred in two feces. One of these was collected from a streamside site where a radio-collared bear had been seen fishing the day before. Digging for Columbian Ground Squirrels (*Spermophilus columbianus*) was recorded infrequently (less than 30 fresh excavations datable to semi-monthly period were observed). Five observations were made where Grizzly Bears fed on the carcasses of large mammals. These included a horse which fell and died on 4 July 1981. A radio-collared bear found this carcass on 8 July and remained there until 28 July.

Feeding Habitat

Yellow Hedysarum

Most Yellow Hedysarum digging sites in the study area were recorded on steep, xeric meadow with southeast through northwest exposure. Seventy-

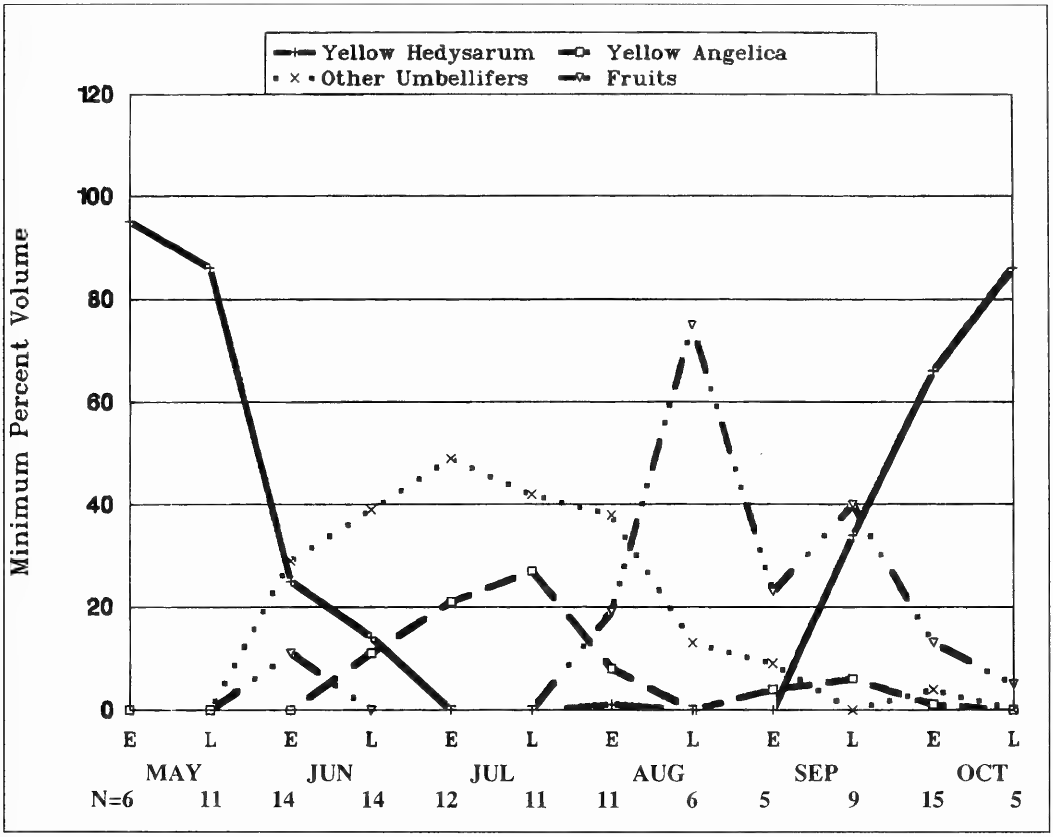

FIGURE 1. Minimum percentage volume of four major foods in 119 Grizzly Bear feces collected by semi-monthly period during 1981-1983. E = Early; L = Late; n = number of feces analyzed

three percent of our classified digging records had this southwest exposure (225° ± 90°). Slopes >24° composed 80% of the classified records. Most records (84%) were in sites between 1700–2100 m. The steep slopes, southwesterly aspect, and upper elevation of most hedysarum digging areas contributed to xeric site conditions through increased solar radiation and exposure into chinook wind. Also leading to xeric conditions was the well-drained, often colluvial, soil. Fifty-five percent of the digging records were classified as being in sites where colluvium was a noted habitat characteristic.

A canopy of immature Lodgepole Pine (*Pinus contorta*) was characteristic of 21% of the Yellow Hedysarum digging records: 12% percent of the digging records were in sites where the forest canopy was estimated as 25% or more, and 9% occurred where the forest canopy was classified as being scattered to 25%.

Bearberry

We observed Grizzly Bears feeding on Bearberries between 1500–2000 m on steep, dry meadow slopes facing southwest (225 ± 90°). Sites with abundant colluvium and xeric scrub were typical Bearberry habitat. Other habitat may have been used: Bearberry feeding could not be recognized from site examination and thus was recorded only during sightings of foraging bears in open habitat.

Glacier Lily/green forage

Feeding for Glacier Lily corms and green forage occurred in mesic to hygric sites, most commonly (>70%) in alder thicket and tall-herb communities of avalanche paths. These mesic avalanche slopes generally had an easterly aspect, with exposure away from the chinook wind (>80% of Cow Parsnip and Glacier Lily feeding observations were on slopes of 0–179° aspect). Some umbellifer feeding occurred in streamside wet-shrub communities. Glacier Lily corm, White Angelica, and Cow Parsnip feeding records also occurred in the forest understory or in glades within the forest community.

The alder and tall-willow (*Salix* spp.) thickets characteristic of many Glacier Lily and green forage feeding sites precluded extensive site investigation. It thus was not possible to quantify habitat use to the same extent as for Yellow Hedysarum where con-

spicuous, long-lasting diggings occurred in xeric sites that could be systematically searched.

Vaccinium

Vegetation in *Vaccinium* feeding sites varied from relatively xeric, chinook-influenced sites with no tall shrubs or trees, to more mesic sites, including avalanche slopes, where tall shrubs such as Menziesia (*Menziesia ferruginea*) and Mountain Ash (*Sorbus* spp.) were abundant. Other sites had abundant Beargrass (*Xerophyllum tenax*; coverage up to 75%). We observed *Vaccinium* feeding in shrubland regenerating from 1919, 1921, and 1935 wildfires. Use of forest types was recorded but was incompletely quantified since *Vaccinium* feeding could not be recognized from feeding signs; our observations were limited to open or semi-open sites where bears could be viewed with telescopes.

Discussion

Our observations of food and habitat used by Grizzly Bears compare with results obtained 250 km north, in Banff National Park (Hamer 1985; Hamer and Herrero 1987a). Although both study areas are in the Front Ranges of the Rocky Mountains, annual precipitation in the Waterton Lakes study area is approximately three times greater (1500 mm versus 500 mm). Differences in vegetation, and accordingly in Grizzly Bear food habits, were observed. For example, umbellifers dominated the early summer diet in Waterton Lakes whereas Cow Parsnip was the only umbellifer present in the Banff study area and was a relatively minor food there (maximum fecal volume of Cow Parsnip in Banff exceeded 10% for only 3 of 48 semi-monthly periods, 1976-1979). In Banff, Horsetail (*Equisetum arvense*) was the major food in early summer. Mace and Jonkel (1986) observed a similar decrease in use of umbellifers coincident with decreasing precipitation.

A major difference in diet also occurred in late summer: *Vaccinium* fruits dominated the diet in Waterton Lakes and Buffaloberries were found in only three fecal samples whereas in Banff, Buffaloberry was abundant in Banff's more xeric habitat types and usually was the major late-summer food. *Vaccinium* fruits were available only in the more mesic, southwest-most corner of the Banff study area and appeared to be a minor food compared to Buffaloberry.

The frequency of ants in the diet also may reflect precipitation. In Banff, ants occurred in 41% (170/418) of the feces analyzed (Hamer 1985). In the more mesic environment of Waterton Lakes, ants occurred in only 6% of the feces analyzed. A positive relationship between xeric microhabitat and an abundance of ants associated with deadwood was indicated in the Banff study area (Hamer 1985:138).

Despite the above differences, similar trends in habitat use occurred: Grizzly Bears in both study areas fed in xeric habitat in early spring and late autumn, and in mesic to hygric habitat in early summer. Hedysarum feeding illustrates this trend for xeric habitat. Hedysarum roots were the most important early spring and late autumn food in both study areas, providing a dependable pre- and post-growing season food source. Digging habitat for Yellow Hedysarum was similar in both areas: typically chinook and colluvium influenced, well-drained, southwest-facing, steep slopes (Hamer and Herrero 1987a; Holcroft and Herrero 1984). [There also were important differences: In Waterton Lakes, 12% of the Yellow Hedysarum diggings were recorded under a forest canopy of immature Lodgepole Pine. In Banff, roots of Pink Hedysarum (*H. alpinum*) from more mesic habitat also were eaten, although Yellow Hedysarum dominated in very early spring and very late autumn when the moister soil of Pink Hedysarum habitat often was frozen and impossible to dig.]

In early summer, mesic to hygric habitat in both parks provided abundant green forage. In Waterton Lakes, mesic generally east-facing avalanche paths (and to a minor extent streamsides and alder-dominated forest openings) were feeding habitat for Glacier Lily corms, Cow Parsnip, and other umbellifers. The abundance of avalanche paths was a conspicuous consequence of the greater precipitation in Waterton Lakes. In the drier environment of Banff, avalanche paths rarely were used as early summer feeding habitat, but streamsides, fens, sidehill seepages, and wet meadows were Horsetail feeding habitat.

In both study areas, fire successional communities were important fruit-producing habitat. In Banff, Buffaloberry feeding sites were in fire successional shrubland and regenerating forest, and all *Vaccinium* feeding sites were in an 1889 burn (Hamer and Herrero 1987b). In Waterton Lakes, undocumented fire(s) (c. 1831-1891) in one upper valley appeared to be instrumental in creating *Vaccinium* feeding habitat used by at least six different Grizzly Bears. Forest re-establishment may have been inhibited by the especially strong chinook winds that characterized this upper valley. *Vaccinium* feeding in Waterton Lakes also was observed in shrubland originating from 1919, 1921, and 1935 wildfires. Martin (1983) found *Vaccinium globulare* fruit production in Montana was greatest in 25–60 year old burns. Some of the wildfires noted above occurred >100 years ago, but development of a forest canopy has been inhibited by other factors.

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Southern Red-backed Vole, *Clethrionomys gapperi*, Populations in Relation to Stand Succession and Old-growth Character in the Central Rocky Mountains

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The effects of old-growth character, microhabitat characteristics, and successional stage on the Southern Red-backed Vole (*Clethrionomys gapperi*) were investigated in conifer forests of southeastern Wyoming in 1986 and 1987. Small mammals were snap-trapped in Lodgepole Pine, mature spruce-fir, and old-growth spruce-fir habitat types. Vole abundance was greatest and body condition best in old-growth spruce-fir. Vole captures best fit a second degree polynomial model when regressed on old-growth rating in 1987; understory cover followed a similar pattern with rating. Abundance was positively correlated with understory cover both years, and because of this relationship and the bimodal response of both of these to old-growth rating, understory cover may influence distribution of *C. gapperi* more than do other habitat features. Vole abundance was positively correlated with stage of decay of logs.

Key Words: Southern Red-backed Vole, *Clethrionomys gapperi*, succession, old growth, Wyoming.

Small mammal populations in forests are functionally related to a wide range of trophic and structural features that may explain their abundance and site-specific fitness. Red-backed voles (*Clethrionomys* sp.) have been shown to fulfill life requisites through association with mesic conditions (Getz 1968), large woody debris (Gunderson 1959; Hayes and Cross 1987), and conifer stands in late successional stages (Tevis 1956; Clough 1987).

The Southern Red-backed Vole (*C. gapperi*) associates closely with conifer-dominated forests of the central Rocky Mountains, and is considered an ecological indicator of old-growth conditions (USDA Forest Service 1985). This close association has been attributed to mesic conditions, which satisfy the high water requirements of *C. gapperi* (McManus 1974) and to understory vegetation, which provides food and water (Schloyer 1977; Martell 1981). Old-growth forest is characterized by large volumes of coarse woody debris (CWD), which provides cover for feeding and reproduction (Maser et al. 1979; Maser and Trappe 1984), pathways for travel (Franklin et al. 1981; Harris 1984), and substrate for the growth of hypogeous fungi, an important source of food and water for red-backed voles (Getz 1968; Maser et al. 1978).

Population attributes of *C. gapperi* in relation to forest succession have not been reported for the Rocky Mountain region. They are of interest in part because of the rapid conversion of old-growth stands to early and mid-seres, and because of the postulated utility of *C. gapperi* as an ecological indicator of old-growth conditions. Herein, we report on population characteristics of the Southern Red-backed Vole as they relate to tree dominants, successional stage, and microhabitat characteristics in conifer forests of the central Rocky Mountains during a two-year period.

Study Area

Field studies were conducted in the upper montane (2300–2750 m) and subalpine (2750 m-timberline) zones of the Medicine Bow Mountains of southeastern Wyoming (41°21' N; 106°12' W) during summers of 1986 and 1987. Lodgepole Pine (*Pinus contorta*) dominated the overstory in the montane zone and the dry south slopes and ridge tops at higher elevations (Romme and Knight 1981). Engelmann Spruce (*Picea engelmannii*) and Subalpine Fir (*Abies lasiocarpa*) were generally codominant in the subalpine zone and succeeded Lodgepole Pine on mesic sites (Alexander 1974; Romme and Knight 1981). Common Juniper (*Juniperus communis*), an understory species found primarily on warm, dry soils (Alexander 1986), was limited to Lodgepole Pine stands, whereas Broom Huckleberry (*Vaccinium scoparium*) was present in the understories of both stand types. Spruce-fir stands exhibited more old-growth character than lodgepole stands. They were uneven-aged, including large, old trees, and had a multi-layered canopy, mesic microhabitats, and large amounts of CWD in the form of snags, downed logs, and rootballs (Buskirk et al. 1989).

Methods

We established twelve study plots in lodgepole and spruce-fir stands on the east and west slopes of the range to test for the effects of successional stage,

TABLE 1. Summary of trapping effort, trapping success, and adult male body weights for *Clethrionomys gapperi* in the Medicine Bow National Forest of Southeastern Wyoming, 1986-1987.

		Study Plots											
		Lodgepole Pine*				mature spruce-fir				old-growth spruce-fir			
Parameter	Year	1	2	3	4	5	6	7	8	9	10	11	12
Trap nights	1986	0	0	0	0	240	400	240	240	240	240	320	24
	1987	240	240	240	240	320	240	240	240	320	320	320	240
Capture success (#/100TN)	1986					1.2	3.2	2.9	2.5	3.3	2.5	2.5	4.2
	1987	9.2	11.7	14.2	37.9	4.7	2.5	4.2	13.3	22.5	13.1	16.2	18.3
Adult male mean body weight in grams (number of specimens)	1986					**	23.2	23.8	19.9	25.4	26.8	21.3	22.2
						(0)	(2)	(3)	(1)	(1)	(2)	(1)	(2)
	1987	19.0	22.7	24.5	21.5	24.0	26.2	**	19.9	25.2	24.6	25.1	24.4
		(5)	(7)	(2)	(6)	(1)	(2)	(6)	(6)	(8)	(9)	(11)	(10)

* This habitat type was not sampled in 1986.
**No adult males were captured.

microhabitat characteristics, and old-growth character, and to control for the effect of major relief. Four plots were sampled in each of three habitat types along a hypothetical successional sequence: early-successional Lodgepole Pine, sampled in 1987 only, mid-successional or mature spruce-fir, and late-successional or old-growth spruce-fir. We set a 1.42-ha trap grid with 80 Museum Special snap-traps (8 by 10, 15-m intervals) on each plot; grid boundaries corresponded to those of the study plots. Traps were baited with peanut butter and oatmeal. From 16 July to 6 September 1986 and from 21 July to 26 August 1987, we trapped each grid for three consecutive nights and collected small mammals each morning (Table 1). If rainfall caused the release of trap mechanisms, trapping effort was extended by as many nights as it rained. Specimens were weighed (Pesola spring scale to nearest 0.1 g), measured (dial calipers to nearest 0.1 mm), and necropsied for sex. Each was assigned to an age class (adult, subadult, or juvenile) based on total body length and pelage characteristics (D. Armstrong, personal communication). Specimens less than 109 mm in length with predominantly gray pelage were classified as juveniles, those 109–131 mm in length with pelage more typical of the adult form were classified as subadults, and those greater than 131 mm with the characteristic red-brown back were classified as adults. Because of the confounding effects of pregnancy, only weights of adult males were used in the analysis (Table 1). Relative abundance of *C. gapperi* was recorded in terms of capture success, i.e., number captured per 100 trap nights (TN) (Table 1).

In summer 1987, we quantified the habitat of each plot. Understory (live vegetation ≤1 m above the forest floor) and log cover (logs ≥0.18 m in diameter) were estimated with the line-intercept method (Cox 1976). Log density was estimated with the point-quarter distance method (Cox 1976) and the diameter of 100 logs was measured for each plot. Stage of decay of each log was categorized using the five classes described by Maser et al. (1979), with class 5 the most advanced state of decay.

An old-growth scorecard developed for the Medicine Bow National Forest (USDA Forest Service unpublished) provided an index of stand condition. Old-growth character is reflected by high scores for the number of tree dominants, diameter at breast height (dbh) of mid-level and overstory trees, canopy cover, density and diameter of downed logs, and density and dbh of snags. Lower scores are indicative of stands in early and mature status. Because the total score is a continuous rather than a discrete variable, we subjectively determined the range of scores for each successional stage: 0–25 (early), 26–43 (mature), and 44–60 (old-growth). We calculated an index for each study plot and treated them as a composite habitat variable in statistical analyses.

We expressed relationships between population characteristics of voles and habitat variables with simple regression and correlation using the study plot as the unit of replication; model-fitting exercises were used to fit understory cover and vole abundance to old-growth rating. The hypotheses that red-backed vole densities and body condition were similar in all habitat types was tested with one-way Analysis of Variance (ANOVA). Significant interactions were further examined using Duncan's multiple range test. Other tests were made with the Chi-square test of independence of rows and columns, and with Student's t-test of independence (two-tailed). Statistical analyses were conducted with the SPSS computer package (Nie et al. 1975) and statistical significance inferred when $P \leq 0.05$.

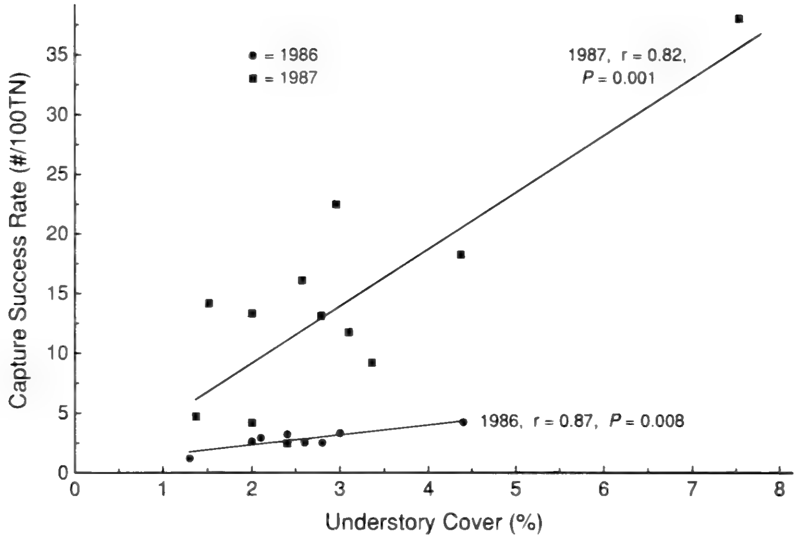

FIGURE 1. Capture success of *Clethrionomys gapperi* in conifer stands in the central Rocky Mountains as a function of understory cover.

Results and Discussion

Clethrionomys gapperi was the only species captured on all grids both years (5360 TN), and represented 73% of 695 total small mammal captures (Nordyke 1988). Captures of other small mammal species were too few to provide a basis for determination of interspecific influences (only 83 *Tamias minimus*, the next most abundant species, were captured; Nordyke 1988). In 1986, mean capture success of *C. gapperi* was low (2.8/100 TN on eight plots) and differed significantly from that in 1987 (14.0/100 TN on twelve plots; t - –3.26, df 18; P - 0.0021). Such flactations in microtine abundance are well documented (Krebs et al. 1973; Vickery et al. 1989). Because of these between-year differences, data for 1986 and 1987 were treated separately in subsequent analyses.

Capture success did not differ significantly between two habitat types in 1986 using the plot as the unit of replication (F = 1.24, df 1, 6; P = 0.31),

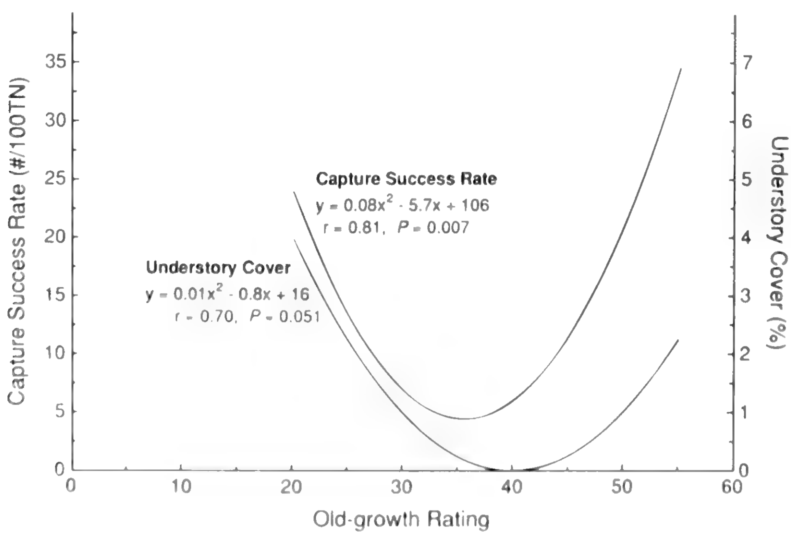

FIGURE 2. Regression of capture success of *Clethrionomys gapperi* and of understory cover on old-growth rating in conifer stands in the central Rocky Mountains in 1987. Data were fitted to the lines using a second degree polynomial model.

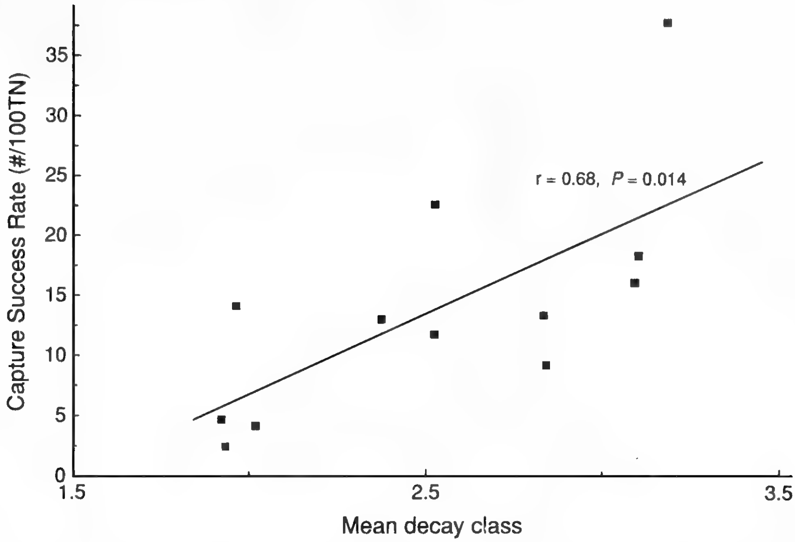

FIGURE 3. Capture success of *Clethrionomys gapperi* in conifer stands in the central Rocky Mountains as a function of mean decay class of logs in 1987.

or among three habitat types in 1987 ($F = 2.56$, df 2, 9; $P = 0.13$). However, in a more powerful Chi-square analysis, in which trap station was used as the unit of replication, capture success was associated with habitat type in 1987 ($\chi^2 = 70.5$, df 2; $P < 0.001$). All pairs of habitat type differed significantly in subsequent 2 X 2 Chi-square comparisons, with mature spruce-fir showing the lowest, and old-growth spruce-fir the highest capture success of red-backed voles, in contrast to the results found by Kirkland (1977) in West Virginia.

Correlation of abundance with understory cover explained 70% of total variation in capture success in 1986 ($r = 0.87$, $n = 8$; $P = 0.008$) and 67% in 1987 ($r = 0.82$, $n = 12$; $P = 0.001$, Figure 1). Because understory cover was provided primarily by young conifers, which do not provide important foods (Martell 1981), responses of voles to understory cover may be attributable either to predator escape cover provided by low branches, or to increased microhabitat moisture levels created by dense canopy near ground level. Data for understory cover and old-growth rating were fitted by a second degree polynomial model ($r = 0.70$, $n = 12$; $P = 0.051$, Figure 2), indicating that understory was dense in Lodgepole Pine and old-growth spruce-fir habitat types, but sparse in mature spruce-fir. The regression of vole abundance on old-growth rating in 1987 ($r = 0.81$, $n = 12$; $P = 0.007$, Figure 2) showed a similar pattern. These variables were weakly correlated in 1986 ($P = 0.097$), when Lodgepole Pine was not included in the analysis. Apparently, the bimodal response of vole abundance to old-growth condition is largely based on the importance of understory cover, which shows a similar bimodal response to old-growth condition.

Correlations between abundance of *C. gapperi* and density, cover, and mean diameter of logs were not significant, which is not consistent with the findings of Hayes and Cross (1987) for *C. californicus*. However, the correlation of abundance on mean log decay class explained 49% of total variation in capture success in 1987 ($r = 0.68$, $n = 12$; $P = 0.014$, Figure 3). This relationship also is not consistent with findings of Hayes and Cross (1987). Red-backed voles may concentrate burrowing activity near soft, rotten logs for food and cover (Maser et al. 1979); this may be particularly important during periods of high population levels, such as occurred in 1987 on our study area. Because old conifer stands have larger and more decayed logs than young stands (Franklin et al. 1981), they provide a stable source of high quality habitat for *C. gapperi*.

Body weight of adult males did not differ between mature and old-growth spruce-fir habitat types in 1986 ($F = 0.74$, df 1, 10; $P = 0.41$), likely because of small sample sizes ($n = 6$ in each habitat types; see Table 1). The same comparison among three habitat types in 1987 was significant ($F = 8.21$, df 2, 61; $P < 0.001$). Duncan's multiple range test found significant differences in body weights between mature and old-growth spruce-fir ($P = 0.004$) and between lodgepole and old-growth spruce-fir ($P = 0.001$). However, body length did not differ significantly in similar comparisons, suggesting that body condition is affected by habitat type, with voles in the best condition being found in old-growth spruce-fir and the poorest in mature spruce-fir and lodgepole stands.

Populations of *C. gapperi* were not unambiguous indicators of old-growth condition of conifer stands in the central Rocky Mountains. Density of *C. gapperi* had a bimodal distribution over old-growth ratings, with peaks in lodgepole as well as in old-growth spruce-fir. However, voles in the best body condition were found in old-growth spruce-fir, and this may in part be due to cover provided by logs and in part to food resources found near logs in advanced stages of decay. The high abundance, but poor body condition of voles in Lodgepole Pine suggests that this habitat type serves as a dispersal sink for subordinate *C. gapperi* during periods of high population levels. Understory cover, which had the strongest linear relationship with vole abundance, was not linearly related to old-growth rating, nor was it considered in the old-growth scorecard that we used to index old-growth condition.

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Black Bear, *Ursus americanus*, Food Habits in Southwestern Alberta

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Holcroft, Anne C., and Stephen Herrero. 1991. Black Bear, *Ursus americanus*, food habits in southwestern Alberta. Canadian Field-Naturalist 105 (3): 335–345.

Black Bear (*Ursus americanus*) food habits were inferred from scat analyses in 1984 and 1985 along the foothills of the Alberta Rocky Mountains. The dry volume of each scat component was measured. This technique allowed statistical analysis of the variation in volume of a single food item in scats over time. Primary foods were: forbs, Bearberries, Horsetail and mammals in spring; forbs, Cow Parsnip, ants and Buffalo-berries in early summer; Wild Red Raspberries, Buffalo-berries and ants in late summer; and Bearberries, Bog Cranberries, wasps, mammals and forbs in fall. The opportunistic omnivorous nature of the Black Bear is emphasized.

Key Words: Black Bear, *Ursus americanus*, bear foods, scat analysis, Alberta.

Increased use by humans of areas inhabited by Black Bears (*Ursus americanus*) increases the risk of encounters between the two which may result in property damage or injury to humans and disturbance or death of bears. It is necessary to understand the ecology of the Black Bears in individual areas so that human activities can be planned to reduce bear-human conflicts. A consequence of the development of Kananaskis Country, a provincial recreational area along the eastern slopes of the Rocky Mountains in southwestern Alberta, is an increase in recreational facilities, and a rise in human use of this area. However, there has been very little study of Black Bear ecology along the eastern slopes. Here, we report on one aspect of Black Bear ecology in the area, i.e., food habits in the foothills of the eastern slopes, through the application of a scat analysis technique developed by the senior author. This provided an estimate of the actual volume of each scat component. Therefore, we were able to use statistical tests not normally employed in scat analyses. We give an assessment of this technique.

Study Area

The study area (approximately 83 km^2) is located 55 km southwest of Calgary, Alberta, within the provincial recreational area, Kananaskis Country (55°40'N, 114°40'W). This study area extends 20 km north of the Sheep River in the foothill region of the east slopes of the Rocky Mountains. Several campgrounds, picnic areas and trails designed for hiking, horse-back riding and/or all-terrain vehicles exist within the study area.

The foothills region is marked by a series of ridges running northwest-southeast. Elevation ranges from 1310 to 1920 m. The climate is characterized by warm summers (July average: 12.6°C) and cold winters (January average: −11.7°C), although winter temperatures occasionally rise above freezing during the day. The mean yearly precipitation is 500 mm (Anderson 1979). Snow cover usually persists from late October to early April.

Most of the study area falls into the Boreal-Lower Foothills and Subalpine Ecoregions. The Aspen Parkland Ecoregion and the Montane Ecoregion also are represented (Anderson 1979). Lodgepole Pine (*Pinus contorta*) and mixed deciduous-coniferous forest are the dominant forest types in the study area. Fire successional Lodgepole Pine often occurs in large monoculture stands, with either a sparse understory of low shrubs, forbs and grasses or a shrub understory, consisting of such species as Green Alder (*Alnus crispa*) and Buffalo-berry (*Shepherdia canadensis*). Mixed forests of Trembling Aspen (*Populus tremuloides*), Balsam Poplar (*P. balsamifera*), White Spruce (*Picea glauca*) and/or Lodgepole Pine are characterized by such understory species as Buffalo-berry, Showy Aster (*Aster conspicuus*), legumes, Fireweed (*Epilobium angustifolium*), Prickly Rose (*Rosa acicularis*) and White Meadow Sweet (*Spiraea betulifolia*). White Spruce stands tend to occur along creek bottoms and on north-facing slopes. Balsam Poplar occurs along creek bottoms and on poorly drained sites. Understory species of deciduous forests include legumes, Prickly Rose, *Aster* spp., Northern Bedstraw (*Galium boreale*) and Wild Strawberry (*Fragaria virginiana*). Shrub areas consist largely of willow (*Salix* sp.). Willow-birch shrub occurs along creeks and poorly drained areas, while willow-alder-raspberry associations occur sporadically on slopes. Grassland areas include pasture on ranch land, small forest openings and large meadows on south and west-facing slopes or on wide valley floors.

Methods

The food habits study took place in conjunction with a broader study on Black Bear ecology and management. Black Bear scats were obtained during trapping and radio-telemetry procedures and by searching for scats along regularly travelled routes.

Trapping occurred over the summer of 1984 and radio-collared bears were tracked from July through October, 1984, and May through June, 1985. In 1984, there were seven radio-collared adult females and five radio-collared yearling or subadult males. In 1985, there were seven of each with radio-collars.

Tracking of the bears ceased in July 1985 due to the inefficiency of the technique. Instead, field work focused on searching for scats along certain trails throughout the study area an average of once a week. The criteria used to choose the trails were: (1) circular routes so a section was not walked twice; (2) easy repeatability, so that scats found could be aged accurately; (3) distributed throughout the study area and in various cover types. In addition, four scats were collected at den sites in March 1986. These were aged as late September or October scats of the previous year.

Telemetry

The bears were radio-tracked from the ground and triangulation was used to determine the bear's location. When a reasonable radio-location was obtained (i.e., the bearings on the map crossed at one point or formed a triangle covering an area no greater than approximately 0.4 ha), the area was searched for bear scats and evidence of feeding as soon as possible after the bear had moved out of the area.

Scat Collection

Black Bear scats that were estimated to be no older than two weeks were collected. Scats were subjectively aged based on the condition of the vegetation underneath the scat and the wetness of the scat, taking into account the most recent rainfall. Forty-four percent of the scats were associated with trapped bears or radio-locations and therefore could be accurately aged. The entire scat was collected if possible and, if not, an estimate was made of the fraction that was collected. Extraneous material was removed if possible and, if not, was recorded so that it could be disregarded during the scat analysis. The scats were stored in 75% ethanol.

Scat Analysis

Scats were analysed using a procedure that provided dry volume measurements of each scat component. The ethanol solution was drained and excess moisture was squeezed out of the scat. The volume of the scat was determined by volume displacement with water. The scat was then randomly sampled to obtain at least 25% of the wet volume. The sample was separated into its components, which were subsequently dried for approximately one day at 50°C. The dry volume of each sample component and the remaining scat was determined by volume displacement with water. The percent composition by volume of each sample component was calculated and the percent of each component was multiplied by the total dry volume of the scat to obtain an approximate volume of each component in the entire scat. For a more detailed description of the scat analysis technique, refer to Holcroft (1986).

Plant remains were identified by comparison to a reference collection of potential Black Bear plant foods and, if necessary, epidermis mounts. Hair samples were analysed using a hair reference collection and the keys of Moore et al. (1974), Adorjan and Kolenosky (1980), Kennedy (1982) and Kennedy and Carbyn (1981: unpublished Canadian Wildlife Service Internal Report, Edmonton). Microtine teeth were identified by comparison to diagrams in Soper (1964). Beaver (*Castor canadensis*) was used as trapping bait, therefore, its presence in scats was ignored in 1984, when trapping occurred.

Statistical Analysis

Due to differential digestibility among food items, the scat volume of different food items cannot be compared. However, the variation in volume of a single food item over time can be considered and tested. Although the digestibility of plant foods may change with senescence, most are eaten only at certain times of the year. Those that are eaten in different seasons would be more digestible in spring than fall and this must be taken into account when interpreting the data. It is useful to examine the use of a food item over time since the diet of bears is not consistent throughout the year. Therefore, food habits were examined during four periods. The following ecological seasons were created based on the variable occurrence of important food items in the scats over the year: 1 May-15 June (spring), 16 June-25 July (early summer), 26 July-31 August (late summer) and 1 September-31 October (fall). The seasons were separated in this way because to create arbitrary time periods may have resulted in a heavily used food item not appearing important if it was divided equally between two time periods. The obvious differential use of food items among seasons was then subjected to a statistical test to determine significant differences.

The scats from each year were assigned to each season according to the estimated date deposited. The dry volume of each food item was summed for all scats in each season and the percent of each food item in the total dry volume of scats in each season was calculated. These percentages were used in Kolmogorov-Smirnov tests (Zar 1984). The average of the four percentages was used as the expected value in each season. Therefore, the test determined whether a food item, in each season, was used more or less than its average percent volume over the four seasons. A rejection level of $\alpha = 0.05$ was used.

It was not possible to analyse statistically individual forb species in the green vegetation category. Their remains were often too fragmented to separate by species, although there was usually enough evidence to identify the species. Cow Parsnip and

TABLE 1. Comparison of observed percent dry volume of each food item to the average percentage over the four seasons in 1984. (0.0 = trace; 0 = absent)

Food item (% volume)	Spring	Early summer	Late summer	Fall	P*
Green vegetation					
observed	49.2	29.4	1.6	11.0	<0.001
expected	22.8	22.8	22.8	22.8	
Horsetail					
observed	13.0	1.7	0.2	0	<0.001
expected	3.725	3.725	3.725	3.725	
Cow Parsnip					
observed	0	32.6	8.1	6.0	<0.005
expected	11.675	11.675	11.675	11.675	
Grass/grass-like					
observed	3.8	2.3	0.6	2.5	<0.50
expected	2.3	2.3	2.3	2.3	
Ants					
observed	1.4	5.1	4.8	0	<0.50
expected	2.8	2.8	2.8	2.8	
Debris					
observed	3.0	12.1	11.3	0.0	<0.10
expected	6.6	6.6	6.6	6.6	
Mammals					
observed	0.1	0.0	0.4	0	>0.50
expected	0.125	0.125	0.125	0.125	
Bearberry					
observed	29.3	0.0	0.2	77.1	<0.001
expected	26.65	26.65	26.65	26.65	
Wild Red Raspberry					
observed	0	0.0	39.9	2.8	<0.001
expected	10.675	10.675	10.675	10.675	
Buffalo-berry					
observed	0	16.8	29.9	0	<0.005
expected	11.675	11.675	11.675	11.675	
Vaccinium sp.					
observed	0	0	1.7	0	>0.50
expected	0.425	0.425	0.425	0.425	

*Rejection level: probability <0.05.

horsetail were exceptions since they were easily recognized and separated, and therefore were statistically analysed separately. Only items that had a measurable representation (i.e., at least 0.1 ml) in at least 25% of the scats analysed in either year were statistically analysed. Others were considered to not occur in enough abundance or frequency in scats to justify statistical analyses. Data on these items were subjectively analysed and described. In addition, the percent frequency of occurrence of each food item in each season was determined.

Results and Discussion

Hatler (1972) compared stomach analyses to scat analyses and concluded that a good collection of scats could serve as a base for nearly any bear food habits study. Certain items lost more volume than others in the digestive system (e.g., animal matter and blueberries versus green plant material and fruits having a large proportion of resistant material). Similarly, Szalai and Stardom (1987: unpublished Manitoba Natural Resources Technical Report No. 87-7, Winnipeg) concluded that scats give an accurate indication of Black Bear food habits, although accuracy is increased if stomachs are used as well.

A total of 69 and 70 scats were collected and analysed from the 1984 and 1985 field seasons, respectively. In 1984, 9, 22, 34 and 4 scats were from the spring, early summer, late summer and fall seasons, respectively. In 1985, 8, 21, 28 and 13 scats were from these same seasons, respectively.

The food items that were used in one or more seasons either more or less than their average percent-

TABLE 2. Comparison of observed percent dry volume of each food item to the average percentage over the four seasons in 1985. (0.0 = trace; 0 = absent)

Food item (% volume)	Spring	Early summer	Late summer	Fall	P*
Green vegetation					
observed	71.5	19.6	6.2	3.2	<0.001
expected	25.125	25.125	25.125	25.125	
Horsetail					
observed	5.7	1.6	1.1	0.0	<0.10
expected	2.1	2.1	2.1	2.1	
Cow Parsnip					
observed	2.0	16.0	1.1	0	<0.001
expected	4.775	4.775	4.775	4.775	
Grass/grass-like					
observed	9.9	4.1	0.2	0.6	<0.005
expected	3.7	3.7	3.7	3.7	
Ants					
observed	1.4	14	8.1	0.0	<0.10
expected	6.025	6.025	6.025	6.025	
Wasps					
observed	0	0.1	1.0	10.6	<0.001
expected	2.925	2.925	2.925	2.925	
Debris					
observed	2.9	31.6	5.2	12.2	<0.05
expected	12.975	12.975	12.975	12.975	
Mammals					
observed	6.4	3.2	0.3	17.3	<0.001
expected	6.8	6.8	6.8	6.8	
Bearberry					
observed	0	0.2	1.8	42.0	<0.001
expected	11.0	11.0	11.0	11.0	
Wild Red Raspberry					
observed	0.0	0.0	54.6	0.0	<0.001
expected	13.65	13.65	13.65	13.65	
Buffalo-berry					
observed	0	8.5	7.1	0	<0.50
expected	3.9	3.9	3.9	3.9	
Vaccinium sp.					
observed	0	0.0	9.3	12.7	<0.001
expected	5.5	5.5	5.5	5.5	

*Rejection level: probability <0.05.

age over the four seasons of 1984 included green vegetation, horsetail (*Equisetum* spp.), Bearberry (*Arctostaphylos uva-ursi*), Cow Parsnip (*Heracleum lanatum*), Wild Red Raspberry (*Rubus idaeus*) and Buffalo-berry. Those that were used at an average rate over the seasons included grass and grass-like plants, ants, mammals and debris (Table 1). Results were similar in 1985 (Table 2), except that horsetail and Buffalo-berry were not used more or less than their average percentage over the seasons and grass and grass-like plants, mammals, wasps and debris were. A Kolmogorov-Smirnov test was performed on *Vaccinium* spp. in 1985 since their abundance was sufficient to justify an analysis. They were used differentially over the seasons as well. Figure 1 displays graphically the percent volume of each major scat component over the seasons of both years.

Food Items

Herbaceous Matter. Herbaceous matter formed the largest part of the diet in spring and early summer, consisting primarily of forbs and, to a much lesser degree, grasses and grass-like plants. Earlier phenological stages may have been selected because nutrient quality is generally highest at these stages (Hamer and Herrero 1983).

The frequency of occurrence of green vegetation in scats was high throughout the year (Table 3), but volumes were greatest in spring, when they were

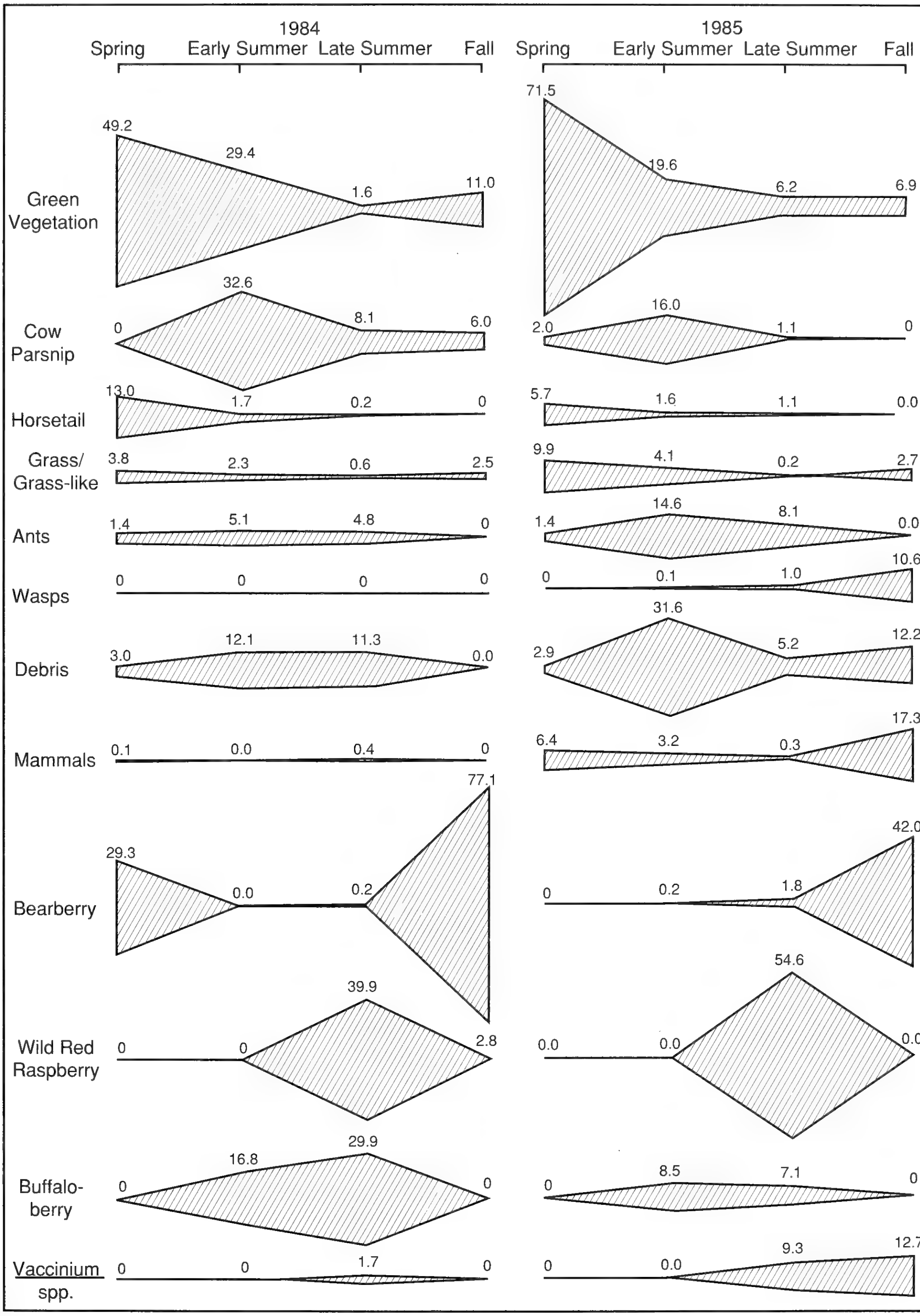

FIGURE 1. Percent dry volume of each major scat component over the seasons in the 1984 and 1985 scats.

TABLE 3. Percent frequency of occurrence by season of each major scat component in the 1984 and 1985 scats.

	1984				1985			
Component	spring n = 9	early summer n = 22	late summer n = 34	fall n = 4	spring n = 8	early summer n = 21	late summer n = 28	fall n = 13
Green vegetation	100	100	82	100	88	100	93	85
Horsetail	56	64	35	–	50	62	32	8
Cow Parsnip	–	91	74	25	25	57	36	–
Grass/grass-like	100	100	91	100	100	91	79	54
Ants	89	86	71	–	75	86	86	23
Wasps	–	–	–	–	–	29	68	77
Debris	89	73	82	25	75	100	89	85
Mammals	11	9	15	–	88	57	50	85
Bearberry	22	5	71	50	–	33	29	54
Wild Red Raspberry	–	5	62	25	13	14	71	8
Buffalo-berry	–	32	56	–	–	43	29	–
Vaccinium spp.	–	–	29	–	–	10	71	62
Ribes spp.	–	5	50	–	–	5	54	8
Prickly Rose	–	–	6	25	–	–	4	39

used more than expected, and lowest in late summer (Tables 1 and 2). The dominant species included the legumes Pea Vine (*Lathyrus ochroleucus*), Wild Vetch (*Vicia americana*) and Pink and Yellow Hedysarum (*Hedysarum alpinum* and *H. sulphurescens*, respectively) and dandelion (*Taraxacum* sp.) (Table 4). Herbaceous dicots have also been found to be primary foods in spring and early summer by Nagy and Russell (1978: unpublished Canadian Wildlife Service Report, Edmonton), Graber (1982), Shaffer (1971), Hatler (1967) and Reynolds and Beecham (1980). On the other hand, forb use occurred year round in Montana (Tisch 1961), and predominated in summer in Wyoming (Irwin and Hammond 1985) and southeastern British Columbia (Lloyd and Fleck 1977: unpublished British Columbia Fish and Wildlife Branch Report, Cranbrook).

Cow Parsnip received highest use in early summer, when it was used more than expected, and lowest use in spring and fall, as indicated by volume and frequency in the scats. Only stem remains were found in scats. In Montana and southeastern British Columbia, Cow Parsnip was used in spring as well as summer, and both stems and leaves were eaten (Tisch 1961; Shaffer 1971; Lloyd and Fleck 1977: unpublished British Columbia Fish and Wildlife Branch Report, Cranbrook). However, in Wyoming it was important from 1 July to 15 August (Irwin and Hammond 1985).

Equisetum arvense and *E. pratense* were the main species of horsetail encountered in scats. Their volume was higher than expected only in spring when they formed a minor part of the diet. However, their frequency of occurrence was highest in early summer. Similarly, horsetail was secondary in importance to other herbaceous matter in spring and early summer and unimportant in fall in central Alberta (Nagy and Russell 1978: unpublished Canadian Wildlife Service Report, Edmonton) and was a minor spring food in Yosemite National Park (Graber and White 1983). In contrast, horsetail was used in all seasons and at high volumes in interior Alaska but received highest use in spring/early summer (Chatelain 1950; Smith 1984).

Grasses and grass-like plants occurred at low volumes in most scats although their frequency of occurrence was high throughout all of the seasons (Table 3). However, in spring 1985, they did occur in scats at higher volumes than expected (Table 2). A variety of grass species were eaten, but bluegrass (*Poa* spp.) predominated. Sedges and rushes were found in few scats and only at trace levels. These results are in sharp contrast to those of many other studies. Other studies have found grasses and/or sedges to be primary spring and/or early summer foods and, in some areas, used through fall (Tisch 1961; Erickson 1967; Hatler 1967; Shaffer 1971; Lloyd and Fleck 1977: unpublished British Columbia Fish and Wildlife Branch Report, Cranbrook; Reynolds and Beecham 1980; Graber 1982; Grenfell and Brody 1983; Smith 1984; Irwin and Hammond 1985). In central Alberta, grasses and sedges rose to some importance only in June and July (Nagy and Russell 1978: unpublished Canadian Wildlife Service Report, Edmonton).

Root material comprised less than 1% of one scat from late summer and one from the fall of 1984. In addition, evidence of digging for legume roots was found on two occasions at the radio-locations of a young female Black Bear. Bulbs, corms and Hedysarum roots are important foods of the Grizzly Bear (*Ursus arctos horribilis*) (Pearson 1975; Hamer and Herrero 1983), but they seldom occur in the diet of Black Bears, who have neither the long claws nor the musculature to enable them to dig up food items

TABLE 4. Percent frequency of occurrence of each green vegetation item and each mammal species over the seasons in the 1984 and 1985 scats.

	1984				1985			
Species	spring n = 9	early summer n = 22	late summer n = 34	fall n = 4	spring n = 8	early summer n = 21	late summer n = 28	fall n = 13
Green Vegetation:								
Pea Vine	100	73	44	75	50	38	21	–
Wild Vetch	89	36	9	–	63	57	32	8
Pea Vine or Vetch	–	–	6	–	–	–	11	–
Hedysarum	33	41	6	–	25	38	21	8
Dutch Clover	22	–	–	–	50	5	4	23
Alsike Clover	–	5	–	25	–	19	4	–
Dutch/Alsike Clover	–	–	–	–	–	–	4	–
Legume (unidentified)	–	–	–	–	–	–	–	8
Dandelion	89	73	9	25	88	62	29	15
Lousewort	33	36	21	25	–	5	11	–
False Dandelion	11	5	3	–	50	14	11	–
Sweet Cicely	11	9	–	–	13	–	18	–
Fireweed	–	–	3	–	–	–	4	–
Woolly Hawkweed	11	–	–	–	13	–	–	–
Meadow Rue	–	–	–	–	38	–	–	–
Yellow Avens	–	–	–	–	13	5	4	–
White Camas	–	–	–	–	13	–	–	–
Northern Bedstraw	–	5	–	–	–	–	–	8
Aster	–	–	3	–	–	–	–	–
Wild Strawberry	–	–	3	–	–	5	4	–
Milk Vetch	22	9	3	–	–	–	–	–
Dewberry	22	–	–	–	–	–	–	–
Anemone	–	–	–	–	–	–	4	–
Willow	–	–	–	–	–	–	11	8
Balsam Poplar catkin	–	–	–	–	–	5	–	–
Unidentified species	44	27	32	25	38	52	32	38
Mammals:								
Moose	–	5	–	–	38	5	–	46*
Moose calf	–	–	3	–	13	–	–	–
Mule Deer	–	5	–	–	13	–	7,7*	8
Mule Deer fawn	–	–	–	–	–	5	–	–
Whitetail Deer	–	–	3	–	–	10	4	–
Elk subadult	–	–	–	–	–	5*	–	–
Unidentified ungulate	–	–	–	–	–	5	18,4*	–
Bighorn Sheep	–	–	–	–	–	–	7	–
Domestic cow	–	–	–	–	13	5	–	–
Bat	–	–	–	–	–	–	4	–
Boreal Redback Vole	–	–	3	–	–	5	–	–
Water Vole	–	–	3	–	–	–	4	–
Microtus sp.	11	–	–	–	–	5	–	–
Ground Squirrel	–	–	–	–	–	–	4	–
Least Chipmunk	–	–	3	–	–	–	4	–
Beaver	–	–	–	–	38	10	–	8
Beaver or Muskrat	–	–	–	–	13	–	4	–
Bushytail Woodrat	–	–	–	–	–	–	4	–
Snowshoe Hare	–	–	3	–	–	–	–	8
Coyote	–	–	–	–	–	–	4	–
Lynx	–	–	–	–	–	–	4	–

*Definitely carrion

easily (Herrero 1985). This study supports the view that roots are not important in the Black Bear diet.

Insects. Ants (Formicidae) were the most important insect food in the study area. Their use was not significantly different among the seasons (Tables 1 and 2), but they received highest use in early summer and lowest use in spring and fall. However, there was a high frequency of occurrence of ants in all seasons except fall (Table 3). Other researchers have also found ants to occur in low volumes but

high frequencies in spring scats and higher volumes in mid-summer scats (Lloyd and Fleck 1977: unpublished British Columbia Fish and Wildlife Branch Report, Cranbrook; Smith 1984; Irwin and Hammond 1985).

Wasp volumes were significant only in the fall of 1985. Wasps show strong year-to-year fluctuations in numbers (Graber 1982), which may explain why they were only present in the 1985 scats. Similarly, Lloyd (1979) observed feeding on wasp nests in only the second of his two-year study in coastal British Columbia. Wasps were important insect foods from late summer through fall in Alaska, California and Wyoming (Hatler 1967; Grenfell and Brody 1983; Irwin and Hammond 1985). However, in Montana, wasps were taken in summer, but less frequently in the fall (Tisch 1961).

Other insects used but to a lesser degree included grasshoppers (Acrididae) and bees. Murie (1937) noted use of grasshoppers and crickets in the summer in Wyoming in a year when they were particularly abundant. Tisch (1961) and Graber (1982) reported bee remains in scats. Digested maggots were found occasionally in association with mammal remains. Their presence was assumed to indicate carrion feeding.

Debris. Debris consisted of a variety of items largely in association with ant and wasp ingestion, including gravel, soil, conifer needles, cones, bits of decayed leaves, twigs, Poplar bud scales and wood chips. This material was likely ingested incidentally, given the foods it was associated with and its poor or non-existent nutritional value. Debris in association with feeding on other items has been observed by Tisch (1961), Graber (1982) and Smith (1984).

Fruit. Fruits were consumed as soon as they became ripe. They were important foods from early summer to fall. Bearberry was also eaten in spring. Berries are one of the primary foods that bears fatten on prior to denning (Herrero 1985).

Wild Red Raspberry was one of the most abundant berry species in the study area and occurred at the highest volumes in scats. Its volume in scats was higher than expected only in late summer. In other studies, *Rubus* spp. have not been found to be important berry foods (Erickson 1967; Kelleyhouse 1975; Graber 1982; Smith 1984). However, Salmonberry (*R. spectabilis*) was an important summer and fall food in coastal British Columbia (Lloyd 1979).

Buffalo-berry was used from the latter portion of early summer to the beginning of late summer and occurred at higher volumes than expected during both of these time periods. Buffalo-berry abundance in the study area was comparable to that of Wild Red Raspberry. Buffalo-berry frequently is recorded as an important Black Bear food, especially in summer (Lloyd and Fleck 1977: unpublished British Columbia Fish and Wildlife Branch Report, Cranbrook; Reynolds and Beecham 1980; Irwin and Hammond 1985).

Vaccinium spp. were not as abundant in the study area as the above two species. Dwarf Bilberry (*V. caespitosum*) was the most common species found in scats and in the study area. It was used primarily in late summer. Volumes were generally low in scats. Bog Cranberry (*V. vitis-idaea*) was found in fall scats. Its berries are known to over-winter well, but no spring use was observed. Chatelain (1950) found it to be used year-round. Similarly, Smith (1984) found it to occur in more scats than any other food. It was the only berry that occurred above extremely low frequencies and volumes in spring/early summer.

Bearberry fruit was also available in the fall and spring. Spring-feeding was noted only in 1984. It appeared to be more important in fall, when occasionally high volumes were encountered in scats. Bearberry abundance in the study area was slightly higher than that of Buffalo-berry and Wild Red Raspberry. In other areas, Bearberries were used in spring and/or fall (Tisch 1961; Pelchat 1979; Grenfell and Brody 1983).

Several other fruits occurred in scats but at low volumes. *Ribes* spp. (Currants and Gooseberries), Saskatoon (*Amelanchier alnifolia*), Twisted-stalk (*Streptopus amplexifolius*) and Bracted Honeysuckle (*Lonicera involucrata*) were used in late summer and Rose hips were used in the fall. Only Prickly Rose was abundant in the study area.

Mammals. Mammal remains were generally low in volume in the scats, and consisted of fur, bones, teeth, claws and occasionally pieces of gut. The species identified in the scats are listed in Table 4. Just a few bear hairs were found in some scats. It was assumed that they were ingested as a result of grooming.

More mammal remains were found in the 1985 scats. They occurred in 47 of the 70 scats, versus 8 out of 69 scats in 1984. Twelve scats in 1984 contained Beaver remains. Beaver definitely was identified in spring, early summer and fall scats of 1985. These results suggest that possibly some of the Beaver in the 1984 scats may have represented feeding on Beaver not used as trapping bait.

Mammals were used differentially over the seasons only in 1985 (Tables 1 and 2) when their volume in scats was higher than expected only in fall. In general, they did not appear to represent an important dietary component. However, scat volumes very likely greatly underestimated the volumes consumed. Smith (1984) claimed that a dozen hairs can potentially represent several kilograms of meat. If mainly viscera from a carcass is eaten, only a few hairs might be found in subsequent scats.

Frequency of occurrence of mammals was highest in spring, but the dietary importance did not appear to vary much throughout the seasons. Other studies have indicated that mammals are most important in spring, when the young are fed on, and in fall, when hunting results in injured animals or carcasses (Schlegel 1976; Graber 1982; Grenfell and Brody 1983; Smith 1984; Irwin and Hammond 1985). It is uncertain whether the mammal remains represented predation, carrion-feeding or incidental ingestion.

Reports on the importance of meat to Black Bears and the bears' role as a predator vary, but there is growing evidence that meat can be a major food of the Black Bear (Schlegel 1976; Franzmann et al. 1980; Schwartz and Franzmann 1983; Smith 1984; Mahoney 1985). Compared to specialized predators, however, bears are inefficient, relatively unsuccessful predators of large mammals (Herrero 1985). Cannibalism is generally infrequent. It consists mostly of predation on cubs and scavenging on carcasses (Chatelain 1950; Tisch 1961; LeCount 1987). Mahoney (1985) reported cannibalism and attempted cannibalism among Black Bears of Newfoundland.

Birds. Bird remains (feathers and egg shells) were very rare in scats. Preying by Black Bears on various birds and their eggs has been reported by Dixon (1927), Rowan (1928), Tisch (1961), Hatler (1967), Graber (1982) and Smith (1984).

Garbage. The volume and frequency of garbage in scats was very low. Just a trace of plastic bag was found in one scat but 11% by volume was found in another. Evidence suggested that unnatural food played a very small role in the Black Bear diet. In contrast, human-origin food comprised 15% of the Black Bear diet in Yosemite National Park (Graber 1982). Minimal use of garbage was found in California (Grenfell and Brody 1983) and Montana (Tisch 1961).

Moss. Moss occurred in low volumes throughout the seasons and was believed to be ingested incidentally. Similarly, Smith (1984) found trace amounts in scats from the Kenai Peninsula, Alaska and considered them to be incidental.

Assessment of Scat Analysis Technique

The technique used in analysing the scats is useful if the results are to be subjected to statistical tests because it gives an estimate of the actual volume of each item. However, it is very time-consuming. Depending on the size and content of the scat, it took from 4 to 65 hours to complete the analysis of one scat. This included the initial draining of the alcohol to the final dry volume measurements (not counting drying time). On average, analysis time was approximately 25 to 30 hours per scat.

Obviously, the more of the scat that is analysed, the more accurate the volumes calculated. The decision to analyse 25% of each scat was arbitrary. Analysing a larger portion would have been much too time-consuming in the case of large scats. Therefore, the decision to use this technique depends on the level of accuracy required and the time available.

Conclusions

Although the small sample size of spring scats precludes definitive conclusions regarding spring food habits, the evidence suggests that the primary food was green vegetation, comprising at least half of the total volume of spring scats. Pea Vine, Wild Vetch and dandelion were eaten most frequently, but several other forbs also were eaten. Other foods included Horsetail, Bearberry, grass, mammals and ants.

In early summer, green vegetation and Cow Parsnip were the primary foods, comprising over half the volume of nutritive scat components. Pea Vine, Wild Vetch, Hedysarum and dandelion were the most used forbs of the green vegetation category. Ants were common food items at this time and Buffalo-berry was used in the latter half of the season. Horsetail, grass and mammals were minor food items.

Wild Red Raspberry was the primary food in late summer, comprising almost half the volume of nutritive scat components. Buffalo-berry continued to be used through the first half of this season, and *Vaccinium* spp. and ants also were eaten. Cow Parsnip and other green vegetation declined in use from early summer. Minimal use of other berries (*Ribes* spp., Bearberry, Prickly Rose, Saskatoon-berry and Twisted-stalk), wasps, Horsetail and mammals occurred.

The small sample size of scats in the fall precludes definitive conclusions regarding fall food habits. Based on the evidence obtained, Bearberry, Bog Cranberry, wasps (in one year), mammals and green vegetation were primary foods. Prickly Rose, grass, Cow Parsnip and Wild Red Raspberry also were used. It is likely that carcasses and injured animals left by hunters are ingested.

The results of this study emphasize the role of the Black Bear as an opportunistic omnivore. Preferred foods were eaten when encountered, e.g., berries and mammals. Although certain forbs may be preferred, others were ingested when encountered. Specific phenological stages were preferred, such as early growth stages of Horsetail, grasses and most forbs and middle growth stages of Cow Parsnip. There also was pronounced yearly variation in food habits. Most notable was the use of wasps, presumably in years when they are abundant. The importance of mammals and certain forb species also varied between years.

The bears were somewhat selective in terms of the parts of plants they ate, e.g., stems of Cow Parsnip

and fruit of shrubs and some forbs, but scat analyses suggested that there was no specific selection for the leaves, stems or flowers of most forbs. Field observations of forbs that had been fed on suggested that primarily the tops of forbs are eaten. This may be due to higher nutrient content or easier digestibility. Vegetation near the peak of its nutrient availability and that is easy to digest typically is eaten (Hamer and Herrero 1983). High nutrient content is important, since reproductive success of females and males is strongly related to nutrition (Herrero 1985).

Bear movements are primarily related to food availability (Herrero 1985). Therefore, a knowledge of food habits in a particular area is an important management tool. For example, campgrounds and trails can be planned to avoid important feeding areas. In addition, facilities may be closed during certain times of the year when the bears are using habitat types containing certain foods, e.g., buffalo-berries in mid-summer. In the event that a key berry crop should fail one year, bag limits could be adjusted to result in a minimal impact on the bear population.

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Impacts of Fire on Bird Populations in a Fescue Prairie

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Breeding bird populations were monitored for three years after an October prescribed burn in a fescue grassland near Saskatoon, Saskatchewan. Breeding populations of 12 species were recorded on a 12.9 ha burned plot and an adjacent 5.6 ha unburned plot, each with similar vegetation. The two most common species, Savannah Sparrow (*Passerculus sandwichensis*) and Clay-coloured Sparrow (*Spizella pallida*) were both adversely affected by the burn. By the third post-burn year, density of Savannah Sparrows was 68% of the value (1.70 pairs/ha) observed in the unburned area, while Clay-coloured Sparrows were only 33% of the density (1.07 pairs/ha) noted in the unburned area. Other important species, Sprague's Pipit (*Anthus spragueii*) and Western Meadowlark (*Sturnella neglecta*) were adversely affected initially by the burn but by the third year, population densities in the burned and unburned areas were comparable. Baird's Sparrow (*Ammodramus bairdii*) did not use the burned area in the first year, but as the grassy canopy became reestablished, the burned area was utilized at moderate densities in the second year, and in the third post-burn year densities were identical in burned and unburned areas (0.27 pairs/ha). Only the Vesper Sparrow (*Pooecetes gramineus*) showed a preference for the burned area in the first year after the burn.

Key Words: Bird populations, fescue prairie, Saskatchewan, fire, Baird's Sparrow, Savannah Sparrow, Clay-coloured Sparrow.

Fire, particularly during the breeding season, can be devastating to ground-nesting birds by destroying nests, eliminating nesting cover, and reducing insect food resources (Daubenmire 1968; Bendell 1974). In the long term, however, fire can be beneficial by increasing the diversity of habitat and wildlife, especially if it occurs outside the breeding season (Stoddard 1963; Wright and Bailey 1982; Driver 1987). In recent years, wildlife managers have used "prescribed burning" as a management tool to modify and diversify habitat, to reduce wildfire hazards by removal of fuel, to release nutrients and thereby improve new plant growth, and to remove accumulated material no longer palatable to grazers (Wright and Bailey 1982).

The objectives of this study were to determine the impact of an autumn burn on the breeding bird population densities in a fescue prairie, and to observe the rate of recovery over a three-year period.

Study Area

Kernen Prairie (E 1/2 8-37-4-W3) is a 130 ha tract of native fescue grassland just outside the city limits of Saskatoon, Saskatchewan (52°10'N, 106°33'W). This native prairie has been only minimally disturbed since the 1930s except for periodic hay-cutting on portions of the prairie until 1976 (Baines 1964; Pylypec 1986).

Plains Rough Fescue (*Festuca altaica* Trin. ssp. *hallii* (Vasey) Harms) is the dominant plant species on the clayey glaciolacustrine soils of the site. Western Porcupine Grass (*Stipa curtiseta* (A. S. Hitch.) Barkworth) and Northern Wheatgrass (*Agropyron dasystachyum* (Hook.) Scribn.) are also important, especially on the slightly elevated upper slopes underlain by sandy loam soils. Several shrub species (e.g., Western Snowberry, *Symphoricarpos occidentalis*; Silverberry, *Elaeagnus commutata*; roses, *Rosa arkansana* and *Rosa woodsii*; and Narrow-leaved Meadowsweet, *Spiraea alba*) are common, particularly in more mesic sites (Baines 1964, 1973; Pylypec 1986; Toynbee 1987). In total, 165 species of vascular plants representing 34 families have been recorded at this prairie (Pylypec 1986).

Methods

An area of 35 ha in the northern part of Kernen Prairie was burned on 17 October 1986. Weather conditions at the time of the burn were: air temperature 23°C, relative humidity 20% and wind SW 18 km/hr.

A study plot, 1000 ft (304 m) × 2000 ft (609 m), divided into 50 sub-plots (Figure 1) was selected to overlap precisely with that used to study bird populations from 1966 to 1970 (Lein 1968; Karasiuk 1973). This allowed comparison of results with pre-burn conditions. The burned portion of the plot covered 12.9 ha while 5.6 ha were not affected by burning. Lein's (1968) study had shown that both areas had a similar vegetation prior to burning.

Breeding birds were censused following the general recommendations of the International Bird Census Committee (Anonymous 1969) developed from the mapping method described by Kendeigh (1944) and Davis (1965). Censuses of approximately 2.5 h duration were conducted twice weekly from 12 May to 5 August 1987, 2 May to 4 August 1988 and 3 May to 9 August 1989.

Results and Discussion

A total of 12 species were recorded as breeding residents on the study plots; ten species occupied

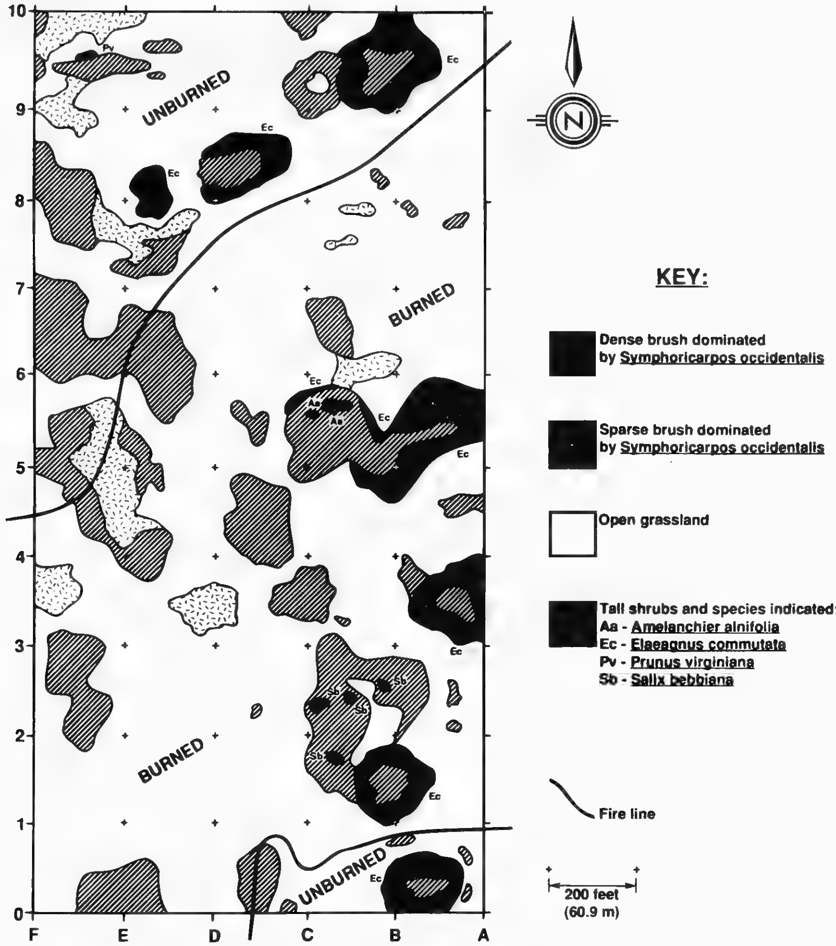

FIGURE 1. Map of study area at Kernen Prairie showing major vegetation types and arrangement of burn and control plots.

both burned and unburned plots while Upland Sandpiper (*Bartramia longicauda*) was recorded only in the burned area and Mallard (*Anas platyrhynchos*) was recorded only in the unburned area (Table 1). All but two species showed the pronounced territorial behaviour necessary for censusing by the mapping method. The Mallard record was based on a nest located in the unburned area, while Brewer's Blackbirds (*Euphagus cyanocephalus*) were recorded in two loose colonies on and adjacent to the study plots. The breeding densities of the latter species were estimated from the maximum number of males observed at any time in the colonies. During the course of the census work, an additional 47 species were observed at the plots either as summer residents nesting elsewhere or as spring migrants.

Total breeding population densities were lower in the burned area than in the control area, especially in the first two years after the prescribed burn (Table 1). In the third year after the burn some recovery in total density was noted with 2.95 pairs/ha present in the burned area compared to 4.24 pairs/ha in the control area. Driver (1987) observed similar results at a fescue grassland at Last Mountain Lake, Saskatchewan, 115 km southeast of Kernen Prairie, though even less recovery in total densities was noted: only one-half of the pre-burn densities were observed three summers later. At a fescue grassland near Drumheller, Alberta, Owens and Myres (1973) reported that disturbance by mowing, grazing or cultivation reduced total bird densities in the following manner: undisturbed site (1.34 pairs/ha), recently mowed site (1.02 pairs/ha), grazed site (0.68 pairs/ha), cultivated land lying fallow (0.19 pairs/ha) and cultivated land seeded to wheat (0.16 pairs/ha).

In mixed grassland of Northern Wheatgrass and June Grass (*Koeleria cristata*) at the Matador

TABLE 1. Maximum density of breeding pairs (number/ha) in burned and unburned areas, 1987-1989.

	Burned Area			Unburned Area		
Species	1987	1988	1989	1987	1988	1989
Mallard, *Anas platyrhynchos*	–	–	–	0.18	–	–
Upland Sandpiper, *Bartramia longicauda*	–	0.08	0.04	–	–	–
Eastern Kingbird, *Tyrannus tyrannus*	0.17	0.14	0.12	0.13	0.13	0.18
Horned Lark, *Eremophila alpestris*	0.06	0.06	0.02	0.04	0.04	0.04
Black-billed Magpie, *Pica pica*	0.06	0.02	–	0.09	0.04	0.09
Sprague's Pipit, *Anthus spragueii*	0.14	0.23	0.25	0.31	0.27	0.31
Clay-coloured Sparrow, *Spizella pallida*	0.43	0.47	0.35	1.43	1.34	1.07
Vesper Sparrow, *Pooecetes gramineus*	0.23	0.04	0.08	0.09	–	0.18
Savannah Sparrow, *Passerculus sandwichensis*	0.81	0.62	1.16	1.70	1.70	1.70
Baird's Sparrow, *Ammodramus bairdii*	–	0.27	0.27	0.54	0.54	0.27
Western Meadowlark, *Sturnella neglecta*	0.19	0.19	0.27	0.36	0.36	0.22
Brewer's Blackbird, *Euphagus cyanocephalus*	0.30	0.35	0.39	0.31	0.80	0.18
Total	2.39	2.47	2.95	5.18	5.22	4.24

research site, Saskatchewan, 175 km southwest of Kernen Prairie, recovery in total population densities was more rapid following an August wildfire caused by lightning (Maher 1973). Densities of 0.72 pairs/ha were noted in the first year after the fire and 2.11 pairs/ha in the second year, compared to densities of 1.14 pairs/ha in nearby undisturbed plots and 2.04 pairs/ha in moderately grazed areas. At the Matador site, burning or a moderate grazing treatment led to increases in total bird densities, due primarily to the preference for disturbed grassland sites by two species, Horned Lark (*Eremophila alpestris*) and Chestnut-collared Longspur (*Calcarius ornatus*) (Maher 1973; Pylypec 1975). These two species were also important in the avian populations studied by Owens and Myres (1973), but in Driver's (1987) study and in this study at the Kernen Prairie, the Horned Lark was an uncommon species while the Chestnut-collared Longspur was not recorded.

At Kernen Prairie, the most common species, Savannah Sparrow, was adversely affected by the burn. Only 48% of the density noted in the control area was recorded in the first post-burn year and 36% in the second year. After three years, the recovery rate was up to 68% of the density (1.70 pairs/ha) observed in the control area in this study and also previously by Lein (1968). This species utilized shrubs for nesting cover and song perches at this site (Lein 1968; Karasiuk 1973), although in south-central North Dakota it occurred only on "shrub-less transects" (Arnold and Higgins 1986). The response of Savannah Sparrow populations may be related to recovery of the dominant shrub, Western Snowberry, after burning. Although some top-killed snowberry plants remained after burning, the density of dead stems was greatly reduced. However, one year after burning, live stem density is equal to or even higher than in unburned areas because of the vegetative growth habit of this species (Anderson and Bailey 1979; Romo and Grilz 1989).

The breeding population of the second most abundant species at Kernen Prairie, Clay-coloured Sparrow, was also adversely affected by burning. Only one-third of the breeding density observed in the control area was recorded in the burned area three years after burning. This species nests in thick shrubbery including Western Snowberry and Silverberry (Knapton 1978; Arnold and Higgins 1986). Western Snowberry recovers quickly after burning, but not Silverberry (Anderson and Bailey 1979; Romo and Grilz 1989). It, therefore, appears that recovery of Clay-coloured Sparrow nesting habitat is still incomplete three years after burning. Similar observations were noted by Driver (1987).

Sprague's Pipit and Western Meadowlark populations were adversely affected by the burn in the first two post-burn years, but by the third year, densities were comparable on burned and unburned areas. These two species feed and nest primarily in open grassland rather than in areas containing much shrubbery (Maher 1973). The recovery in their populations may, therefore, be related to the rapid recovery of the *Festuca-Stipa* grassland community that occurs after a single burn (Bailey and Anderson 1978; Anderson and Bailey 1979). In mixed grassland at the Matador site, Maher (1973) noted that two years after burning, Western Meadowlark populations had recovered to the pre-burn density (0.11 pairs/ha) and that Sprague's Pipit populations were even higher (0.61 pairs/ha) than in the adjacent unburned area (0.45 pairs/ha).

Initial effects of the burn upon the Baird's Sparrow populations were devastating. In the first post-burn year, the species did not use the burned area at all even though moderately-sized populations (0.54 pairs/ha) were present in the adjacent

unburned area. The species occupied the burned area in the second post-burn year at moderate densities, and by the third year, populations were identical on burned and unburned areas. Maher (1973) and Driver (1987) also note the occurrence of this species on burned areas three years after burning. The Baird's Sparrow, an endangered species, is very dependent on a thick canopy for nesting and feeding (Lein 1968; Maher 1973) and does not occupy grassland that is over-grazed, cultivated or recently burned. Its presence, therefore, is a good indicator of the recovery of aboveground grass biomass after a disturbance such as burning.

Only the Vesper Sparrow showed a preference for the burned as opposed to the unburned area in the first year after the burn. This species prefers ecotonal habitat (Owens and Myres 1973), and burned area, though disturbed, still provided suitable habitat including singing perches important for its territorial behaviour.

Of the remaining species, the Eastern Kingbird (*Tyrannus tyrannus*) and Brewer's Blackbird were present in approximately equal numbers on both burned and unburned areas. Four additional species: Mallard, Upland Sandpiper, Horned Lark and Black-billed Magpie (*Pica pica*) were recorded only in low densities at the study plots.

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Winter Sightings of Canada Geese, *Branta canadensis*, Banded in Northern Quebec and James Bay

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Menkens, George E., Jr., and Richard A. Malecki. 1991. Winter sightings of Canada Geese, *Branta canadensis*, banded in northern Quebec and James Bay. Canadian Field-Naturalist 105 (3): 350–353.

January observations of Canada Geese (*Branta canadensis*) neckbanded in three northern Canada breeding areas were used to examine the relationship between goose breeding and wintering distributions and to determine if winter observations could be used to delineate breeding goose populations. Winter distributions of birds from three breeding areas differed and these differences were consistent between 1987-1989. However, all breeding segments overlapped sufficiently in their use of winter areas to preclude their delineation using winter observations alone.

Key Words: Canada Geese, *Branta canadensis*, Atlantic Flyway, breeding populations, neckbands, winter distribution

North American Canada Geese, *Branta canadensis*, are managed on a population basis (Addy and Heyland 1968; Crissey 1968; Kennedy and Arthur 1974; Anderson and Joyner 1985; Tacha et al. 1988). This approach to management is used to enhance populations in specific regions (Crissey 1968; Trost et al. 1986) or to conserve genetically unique groups (Raveling 1969). Because Canada Geese winter generally in discrete groups (Raveling 1978, 1979; Trost and Malecki 1985), goose populations have been defined traditionally by winter distributions (Addy and Heyland 1968; Crissey 1968; Raveling 1969, 1979). Defining goose populations using their wintering distributions has proven effective in documenting changes in population numbers and winter distributions occurring in response to changing land use patterns, climatic events, and user demands in staging and wintering areas. This approach is, however, not always adequate for defining goose populations on either wintering or breeding areas (Anderson and Joyner 1985; Tacha et al. 1988).

Our objectives were to determine the relationships between breeding and wintering distributions of Canada Geese in the Atlantic Flyway and to determine if data collected from these wintering goose distributions alone could delineate breeding populations of Atlantic Flyway Canada Geese.

Methods

During the summers of 1986, 1987, and 1988 adult Canada Geese with young (n = 461, 184, 215 respectively) were uniquely marked with orange and white neckbands and U.S. Fish and Wildlife Service (USFWS) legbands at three sites (Figure 1): Ungava Bay (1986, 1988) and Hudson Bay (1986), Quebec, and James Bay (1987), Ontario. From 1 October to 28 February 1986-1987, 1987-1988, and 1988-1989, observers traveled automobile routes through Delaware, Maryland, New Jersey, New York, North Carolina, Pennsylvania, South Carolina, and Virginia and recorded the neckband number and location to the nearest 10 minute degree block of each neckbanded goose observed. Each state was surveyed every 1–3 weeks. Within a state, observation effort and routes were consistent among years.

We used Mardia's statistic (Mardia 1967) to test the null hypothesis that the January distributions of geese from each banding area did not differ within a year; and to test for annual fidelity to wintering areas among years for each breeding population. Mardia's test is a nonparametric, two sample test that compares the centers of distribution for two groups (i.e., banding locations) by comparing a sample of points (i.e., January observation locations) from each group (Batschelet 1981). In all analyses, if a goose was observed more than once during January, only the first observation was used. Only rarely (< 1%) were geese re-observed outside the 10 minute degree block in which the first January observation was made. When ties in observation locations occurred between groups, we computed Mardia's test statistic following Robson (1968). The number of neckbanded geese observed decreased substantially during the second and third years following marking due to hunting and natural mortality. Neckband retention rates were > 99% (Hestbeck and Malecki 1989), thus the results are not biased by neckband loss.

Results and Discussion

January distributions of neckbanded geese from all three breeding areas differed ($P \leq 0.05$) within each year (Table 1) indicating that geese from the three sampled breeding areas have different wintering distributions. Except for differences in January

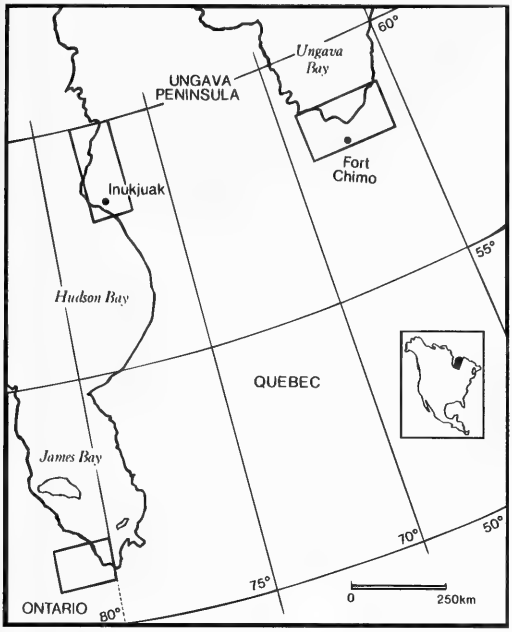

FIGURE 1. Location of Canada Goose breeding areas at which adult geese with young were neckbanded. Geese were neckbanded at Ungava Bay in 1986 and 1988, Hudson Bay in 1986, and at James Bay in 1987.

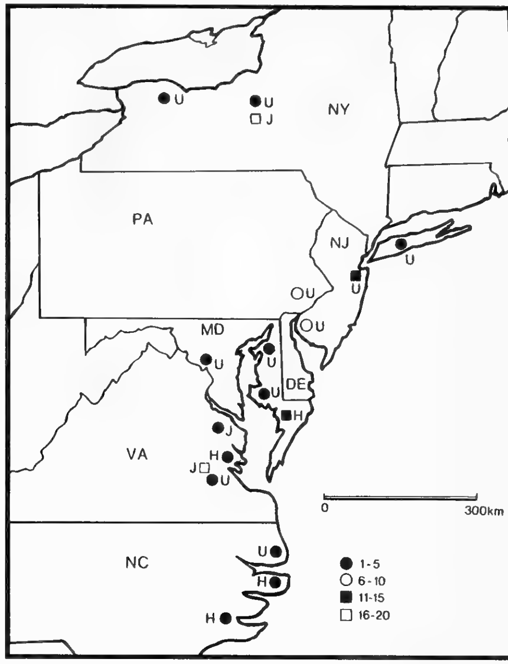

FIGURE 2. Number and distribution of adult Canada Geese observed in January that were neckbanded on breeding areas near Ungava Bay (U) and Hudson Bay (H), Quebec and James Bay (J), Ontario. Symbols indicate the number of geese from each banding area observed.

1987 and 1988 observations ($\chi^2 = 11.67$; $n = 29{,}6$; $P = 0.003$) of geese marked in 1986 on Hudson Bay, the January distributions of birds banded at a banding area did not differ among years (Mardia's test, all $P > 0.05$). All breeding segments exhibited a high degree of overlap during January (Figure 2). For example, marked birds found wintering in central New York included geese from Ungava Bay and James Bay, whereas those wintering on Chesapeake Bay included Hudson Bay and Ungava Bay birds. Such spatial overlap makes it difficult to distinguish or delineate individual breeding populations using data on wintering distributions alone.

Differences in the January 1987 and 1988 observations of geese marked in 1986 on Hudson Bay suggest that large scale population movements may occur between years within regions. Such movements may reflect responses to climatic events (Craven and Rusch 1983; Anderson and Joyner 1985) or possibly changes in resource distribution. We hypothesize that such factors were responsible for a southerly shift in the January distribution of Hudson Bay geese in 1988. These movements further complicate attempts to define individual breeding populations of Canada Geese using only wintering distribution data.

The primary breeding area of Atlantic Flyway Canada Geese extends from the eastern coasts of Hudson and James bays eastward to Newfoundland (Addy and Heyland 1968; Bellrose 1980). Most geese migrate directly from breeding to wintering areas (Menkens and Malecki 1990). Different breeding populations probably possess highly overlapping winter distributions, similar to those reported for the Mississippi flyway (Craven and Rusch 1983; Anderson and Joyner 1985; Tacha et al. 1988). Similarly the overlap coincides with increasing numbers of "resident" geese that occur in segments of the winter range (USFWS Office Migratory Bird Management, unpublished report). We believe that mixing of breeding populations in wintering areas is therefore common and results from geese concentrating in areas of high resource availability and/or areas offering protection from disturbance.

The mixing of breeding segments results in an inability of concerned managers to distinguish specific populations or subpopulations based on winter distribution data. Delineation and monitoring of breeding groups throughout the Atlantic Flyway is needed for the refinement of future management decisions sensitive to breeding group status. Differences in the proportional distribution of breed-

TABLE 1. Mean latitudes and longitudes of January observations of neckbanded adult Canada Geese marked on breeding areas near Ungava (U) and Hudson (H) Bays, Quebec and James Bay (J), Ontario.

Banding site (Banding year)	Observation Year	n	χ Latitude	χ Longitude	χ^2
Ungava and Hudson bays					
U (1986)	1987	59	40.16	75.52	28.69*
H (1986)		29	38.50	76.20	
U (1986)	1988	40	39.83	75.68	12.38*
H (1986)		6	36.25	76.30	
U (1986)	1989	23	40.07	75.46	6.81*
H (1986)		7	38.64	76.28	
Ungava and James bays					
U (1986)	1988	40	39.83	75.68	37.82*
J (1987)		32	39.58	76.94	
U (1988)	1989	23	39.97	75.55	18.72*
J (1987)		19	41.14	77.31	
Hudson and James bays					
H (1986)	1988	6	36.25	76.30	29.76*
J (1987)		32	39.58	76.94	
H (1986)	1989	7	38.64	76.28	14.40*
J (1987)		19	41.14	77.31	

* Mean latitudes and longitudes differed ($P < 0.05$) within a year.

ing groups in wintering areas remains a problem to resource managers in areas where their spatial or temporal distinction is not apparent.

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Elk, *Cervus elaphus*, Habitat Use Related to Prescribed Fire, Tuchodi River, British Columbia

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Prescribed fire has traditionally been used to create and maintain Elk habitat in the Tuchodi River area of northeastern British Columbia. Elk use of post fire vegetation was examined. Elk wintered primarily on younger postburn vegetation dominated by grasses or shrubs, except during severe portions of winter when conifer stands received use. Expansion of grass shrub communities by prescribed burning would reduce seasonal densities and disperse Elk distribution.

Key Words: Elk, *Cervus elaphus*, habitat use, horse, British Columbia, fire, successional stage, boreal spruce.

Fire has a crucial role in creating the diverse vegetational mosaic characteristic of northern boreal forests (Kelsall et al. 1977). A number of herbivores, including Elk, have shown positive responses to post fire vegetation (Bendell 1974; Hornbeck 1985). The northernmost native Rocky Mountain Elk (*Cervus elaphus nelsoni*) in North America inhabit the Muskwa range and foothills of the Rocky Mountains in northeastern British Columbia (Cowan and Giguet 1978). Prescribed fire has traditionally been used to maintain and improve wildlife habitat in the foothill region, and the major Elk wintering areas are associated with these burns (Seip and Bunnell 1985; J. P. Elliott and B. Webster. 1982. Northeastern British Columbia elk enhancement program, Unpublished report. British Columbia Fish and Wildlife Branch, Victoria, B.C., 88 pages + appendices; J. P. Elliott and B. Webster. 1983. Northeastern British Columbia 1982-1983 elk enhancement program. Unpublished report. British Columbia Fish and Wildlife Branch. Victoria, B.C., 68 pages + appendices). Little information is currently available on Elk habitat use of fire maintained habitats in this region. The objectives of this investigation were to evaluate Elk habitat use of the plant communities relative to the prescribed fire activities in the region.

Study Area

An 18 860 ha study area was delineated on the Tuchodi River, a northern tributary of the Muskwa River on the eastern slope of the Rocky Mountains (58°20'N, 124°10'W). Elevations range from 2900 m at the summit of Mt. Sylvia 20 km west of the study area to less than 800 m in the Tuchodi River Valley. Recently retreated glaciers have left a thin mantle of glacial drift and boulders over the region. Specific deposits include lacustrine, morainal, and glaciofluvial materials. Short summers and harsh winters result in deep frost penetration and discontinuous permafrost on some sites. Resultant soils are generally shallow and pedogenically youthful.

The northern continental climate characteristic of northeastern British Columbia is distinguished by long, cold winters and short warm summers (Koppen 1936). The area is influenced by cold polar continental and warm, moist polar Pacific air masses. Mean daily temperatures range from a low of –23.2°C in January to a high of 16.7°C in July. Annual precipitation averages 44.6 cm, with 60% falling as rain from April through October. Snow accumulations in the foothill study area are reduced by periodic chinook conditions, and exposed south and southwest facing slopes are often snow free in mid winter.

Vegetation in the study area falls within Krajina's (1965) boreal White and Black spruce (BWBS), and Spruce-Willow-Birch (SWB) biogeoclimatic zones. An ecological classification of the BWBS was developed by Annas (1977). D. Meidinger and T. Lewis (1983. Biogeoclimatic zones and subzones of the Fort Nelson Timber Supply Area, B.C.: Northern Fire Ecology Project. Unpublished report, B.C. Ministry of Forests. Victoria, B.C. 53 pages) have suggested upper elevational limits for the BWBS of 1050-1100 m in the foothill region.

Within the BWBS, a White Spruce (*Picea glauca*) association is climax on mesic upland sites. Characteristic seral trees include aspen (*Populus tremuloides*), Balsam Poplar (*P. balsamifera*), and Paper Birch (*Betula paperifera*). Typical shrubs are Highbush Cranberry (*Viburnum edule*), Buffaloberry (*Sheperdia canadensis*), and Prickly Rose (*Rosa acicularis*), associated with common herbs such as Hairy Wild Rye (*Elymus innovatus*), Northern Brome (*Bromus inermis* subsp. *pumpellianus*), Lupine (*Lupinus sericeus*), and Fireweed (*Epilobium angustifolium*). The common mosses include Feather

Moss (*Ptilium cristacastrensis*), Stepmoss (*Hylocominum splendens*), and Schreber's Moss (*Pleurozium schreberi*).

On well-drained coarse textured morainal soils, Lodgepole Pine (*Pinus contorta*) stands are prevalent and are associated with Buffaloberry, Canadian Bunchberry (*Cornus canadensis*), Mountain Cranberry (*Vaccinium vitis-idaea*), and Kinnikinnick (*Arctostaphylus uva-ursi*). Feathermosses are common, along with cladina (*Cladina* spp.) lichens. Balsam Poplar, in conjunction with White Spruce is typical floodplain vegetation, often associated with Alder (*Alnus tenuifolia*), willows (*Salix* spp.), Highbush Cranberry (*Viburnum edule*) and Meadow Horsetail (*Equisetum pratense*).

Black Spruce (*Picea mariana*) and to some extent Tamarack (*Larix lariciana*) are representative overstories on poorly drained acidic soils at lower elevations. Understory species include Labrador Tea (*Ledum groenlandicum*), Mountain Cranberry, Lapland Rhododendron, (*Rhododendron lapponicum*), Groundbirch (*Betula glandulosa*) and Bog Blueberry (*Vaccinium uliginosum*). Northern Scouring Rush (*Equistem variegatum*), is usually evident, in conjunction with sphagnum moss (*Sphagnum* spp.).

The subalpine vegetation of northern British Columbia was described within the Spruce-willow-birch (SWB) biogeoclimatic zone by Pojar (1983). Meidinger and Lewis (1983; see above) suggested elevation boundaries for SWB of 1050-1550 m in the foothill region. This zone contains a wide variety of forest and nonforest vegetation, related to aspect, fire history and site conditions.

An open White Spruce, with occasional Subalpine Fir (*Abies lasiocarpa*) forest, associated with a prolific shrub layer dominated by Glaucous Willow (*Salix glauca*), and Groundbirch is considered the climax vegetation on mesic sites. Typical dwarf shrubs/herbs include Mountain Cranberry, Altai Fescue (*Festuca altaica*), and Fireweed. The cryptogamic layer is well developed with feathermosses and cladina and sheet (*Peltigera* spp.), lichens.

On drier sites over coarse morainal materials, Lodgepole Pine in conjunction with Groundbirch is common. White Spruce is often present as regeneration associated with Glaucous Willow and Scouler's Willow (*Salix scouleriana*). Juniper (*Juniper communis*), Kinnickinnick and Mountain Cranberry occur in the dwarf shrub layer in association with Altai Fescue, Lupine, and Fireweed. Feathermosses, and Juniper Haircap Moss (*Polytrichum juniperinum*), are frequent, along with cladina and fruticose lichens (*Cladonia* spp.).

In areas influenced by cold air drainage, recent fire, or at the upper elevations, shrub communities are common. A variety of willows, *Populus* spp. regeneration, and groundbirch dominate these communities, with Altai Fescue and sedge (*Carex* spp.) frequent. Moss layers are often hummocky consisting of Stepmoss, Haircap Mosses, and Heron's Bill Moss (*Dicranum fuscescens*).

Subalpine grasslands on steep south and west facing slopes contain a combination of Glaucous Blue Grass (*Poa glauca*), Altai Fescue, Hairy Wild Rye, Slender Wheatgrass (*Agropyron trachycaulum*), Three-toothed Saxifrage (*Saxifraga tricuspidata*), Prairie Sage (*Artemesia frigida*), and Wormwood (*A. campestris* subsp. *borealis*). Wetter sites are distinguished by species such as Monkshood (*Aconitum delphinifolium*) Jacob's Ladder (*Polemonium acutiflorium*), and Alpine Timothy (*Phleum alpinum*).

Methods

Nine community types (CT) identified in the study area (Peck 1987), were used in the analysis of Elk habitat use. The fire history and characteristic species of these types are presented in Table 1. Five sequential fire history classes (FHC), defined on the basis of years since the last fire through an area, viz. 0-2 years, 3-7 years, 10-20 years, 40 years, and > 100 years were used in the analysis of Elk habitat use in relation to fire history. The area covered by each CT and FHC was planimetrically determined on a vegetation map of the study area (Peck 1987).

Habitat use was determined from pellet group surveys, group observations, and winter aerial surveys. Pellet group surveys allowed comparison of Elk and feral horse habitat use, ground observations examined seasonal Elk activity in relation to habitat, and aerial surveys permitted evaluation of habitat selection by comparing use with availability.

Pellet group surveys were conducted in conjunction with vegetation analysis during the summers of 1980 and 1981. Five 2 m-radius circular plots were randomly located within a CT and intensively searched for Elk and feral horse pellet groups. A part of any pellet group on a plot boundary was considered within the plot. Elk pellet groups were differentiated into summer and winter groups based on shape and texture (Bubenik 1982). For each examination, the mean number of pellet groups/plot was determined, and data summarized for each CT. Differences in mean pellet groups/plot within each CT, by season of deposition for Elk, and between Elk and horses were tested with a t-test at $p = 0.05$.

Elk activity in each CT was determined from observation points along ground survey routes from March 1979 to January 1983. Animals were recorded as either foraging or resting. Traveling, grooming, social interactions, and lick activities were observed but not included in the analysis. Observations were summarized into mid-winter (January, February), late winter (March, April), spring (May), and summer (June, July). Fall and early winter activity patterns were not recorded.

Fixed wing aerial surveys during four consecutive winters, 1978-1979 to 1981-1982, provided

TABLE 1. Description of community types and their fire history on the Tuchodi River study area, after Peck (1987).

Community type	Years since last fire	Tree dominants	Shrub dominants	Herb dominants
Black Spruce	40-100	Black Spruce	Laborador Tea Ground Birch Shrubby Cinquefoil Bilberry Willow	Mountain Cranberry Scouring Rush Altai Fescue Red Manzanita
White Spruce	> 100	White Spruce	rose Buffaloberry Shrubby Cinquefoil	Hairy Wild Rye Northern Hedysarum Northern Twinflower
Spruce-willow	40-100	White Spruce	Glaucous Willow Ground Birch Labrador Tea	Mountain Cranberry Fireweed Lupine Lungwort
Mature poplar	15-100+	Balsam Poplar Quaking Aspen Lodgepole Pine	Buffaloberry rose Balsam Poplar	Hairy Wild Rye Fireweed Lungwort American Vetch Lupine Northern Bedstraw American Vetch
Open poplar	2-20+	Balsam Poplar Quaking Aspen	rose Quaking Aspen Balsam Poplar	Hairy Wild Rye Northern Brome American Vetch Lungwort Fireweed Lupine
Shrub-sapling	6-20	absent	Quaking Aspen Balsam Poplar willow spp. rose	Hairy Wild Rye Northern Brome American Vetch
Young shrub	2-7	absent	Quaking Aspen Buffaloberry Balsam Poplar rose	Hairy Wild Rye Northern Brome Fireweed Lungwort American Vetch
Grass-shrub	3-20	absent	rose Quaking Aspen Balsam Poplar Saskatoon	Hairy Wild Rye Northern Brome Northern Bedstraw American Vetch False Solomon's Seal Yarrow
Grass-herb	0-2	absent	Quaking Aspen Balsam Poplar	Hairy Wild Rye Fireweed Lupine American Vetch Lungwort

information on Elk distribution and habitat use. The study area was delineated into twenty unequal units bounded by identifiable drainages. All units were intensively searched for Elk at elevations of 100-200 m above ground level with flight paths dictated by terrain characteristics.

For each Elk, or Elk group sighted, we recorded group size, composition, CT, FHC, slope, aspect, and snow depth. If data was not recorded, the pilot was instructed to recircle the area. To compensate for differences in visibility between CTs, searching intensity was increased in any area where recent tracks or sign were observed. An instance of use of a CT and FHC was considered as an Elk observation. Immediately following each flight, data were summarized, placed on permanent data sheets, and locations plotted on 1:125 000 topographic maps. Aerial observations were used to test hypotheses

that Elk utilized each CT and FHC in proportion to availability on the study area. Chi-square tests of independence were performed, with observed instances of use of each CT and FHC summarized by flight, and expected use calculated as a product of the portion of the total of each CT and FHC and the number of animals seen per flight. Confidence intervals were calculated at the 0.10 level of significance following Neu et al. (1974) to determine preference or avoidance.

Results

Mean numbers of pellet groups/plot indicated differences in seasonal habitat use by Elk, as well as between horses and Elk (Figure 1). Significant seasonal differences in mean Elk pellet groups were determined for grass shrub, young shrub, and shrub sapling CTs. Although the highest numbers of Elk pellet groups were obtained for the grass shrub CT for both seasons, the values were significantly different only in winter. These data suggest broader habitat use by Elk in summer than in winter. All season mean Elk pellet groups showed significant differences from mean horse pellet groups in grass shrub and young shrub CTs. Horse pellet group numbers were highest in the open poplar type, but no overall differences in use of CTs by horses were apparent. The mean number of Elk pellet groups in the grass shrub CT was significantly higher than all other CTs, and significant differences were also determined between young shrub and open poplar CTs. These data indicate that there is considerable use of grass shrub and young shrub CTs by Elk all year round, whereas horse use is more equally distributed between types.

A total of 16 564 observations of Elk foraging and resting activities were obtained from March 1979 to January 1983. Foraging accounted for 85% of the overall observed activity, although this varied somewhat by seasonal period (Table 2). For all

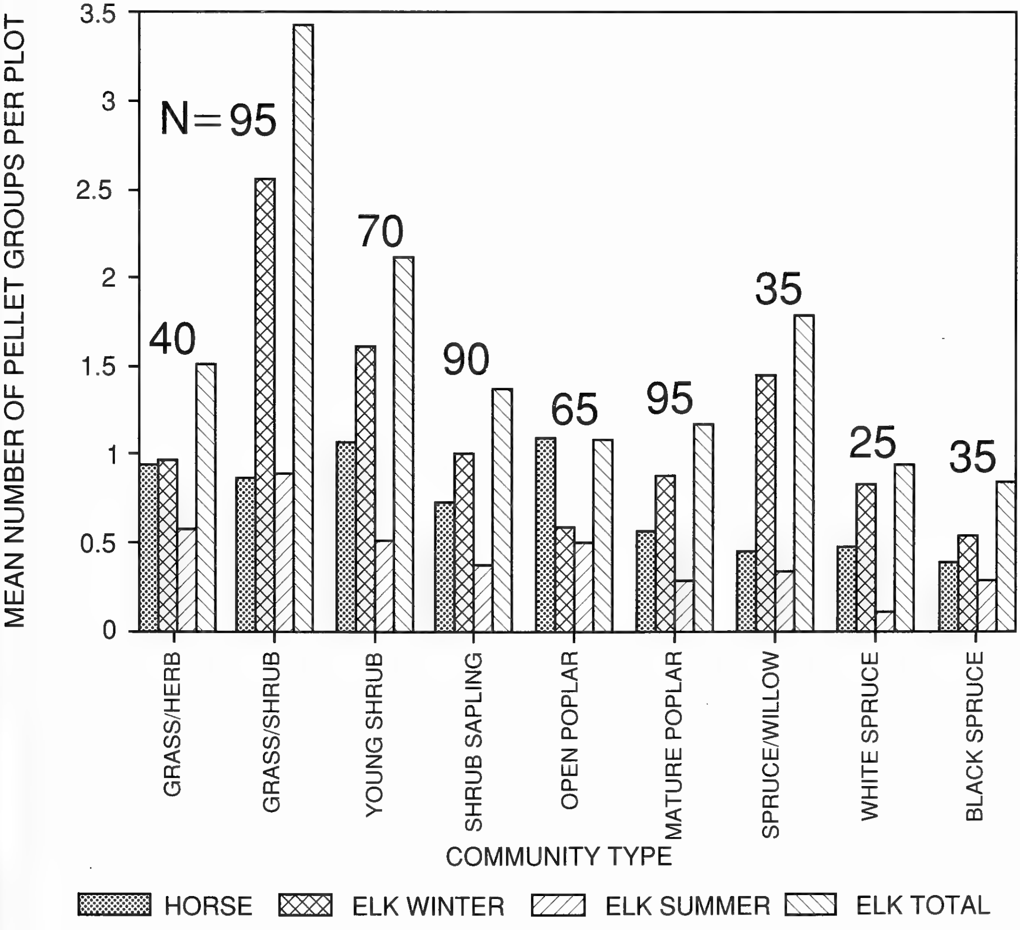

FIGURE 1. Seasonal and total mean Elk pellet and total horse pellet groups/plot by community type.

TABLE 2. Number and percent of ground observations of Elk in community type by season, 1979-1983, Tuchodi River study area.

Community type	Midwinter				Late Winter				Spring				Summer			
	Foraging		Resting		Foraging		Resting		Foraging		Resting		Foraging		Resting	
	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)
Grass-herb	359	9.4	78	9.7	312	5.8	7	0.5	121	4.1	0	0	275	17.2	21	10.0
Grass-shrub	1539	40.5	120	15.0	3188	59.0	598	44.8	1641	55.8	76	44.1	494	31.1	42	20.3
Young shrub	552	14.5	230	28.7	403	7.5	149	11.2	562	19.1	34	19.8	442	27.6	71	34.3
Shrub-sapling	89	2.3	15	1.8	267	4.9	137	10.3	163	5.5	15	8.7	87	5.4	10	4.8
Open poplar	553	14.5	231	28.8	760	14.1	345	25.8	315	10.7	19	11.0	68	4.2	11	5.3
Mature poplar	102	2.7	52	6.5	120	2.2	31	2.3	83	2.8	18	10.5	75	4.6	52	25.0
Spruce-willow	624	16.4	35	6.8	304	5.6	65	4.9	38	1.3	4	2.3	15	9.4	0	0
White Spruce	0	0	20	2.5	19	0.4	3	0.2	3	0.1	0	0	3	1.2	0	0
Black Spruce	2	0.1	0	0	25	0.5	0	0	13	0.4	6	3.5	0	0	0	0
Total (#)	3803		801		5710		1335		2939		172		1597		207	

seasons the greatest proportion of foraging activity was in the grass shrub CT, while the relative proportion of foraging observations in the other CTs changed seasonally. In mid-winter, an additional 55% of foraging observations were in spruce willow, open poplar, young shrub, and grass herb CTs. Foraging observations in the grass shrub CT increased to 59% in late winter, remained at similar levels in open poplar, while declining in spruce willow, young shrub, and grass herb CTs. Observations of foraging in the young shrub CT increased to 20% in the spring, while relative numbers declined in open poplar and spruce willow CTs. While the largest portion of foraging observations in summer were in the grass shrub CT, percentages of observations increased in young shrub, grass herb and spruce willow CTs. Foraging activity was limited in mature poplar, shrub sapling, White Spruce, and Black Spruce CTs, and changed little seasonally.

Observations of resting activities followed similar trends, while proportional use of CTs differed seasonally. Open poplar and young shrub CTs contributed to 56% of the mid-winter resting observations, with a further 25% in grass shrub and grass herb CTs. Observations of resting in the grass shrub CT increased in late winter, in conjunction with a decline in observations in open poplar and young shrub CTs. In spring, proportions of resting observations remained high in the grass shrub CTs, and while increasing in young shrub and mature poplar, continued to decline in open poplar CTs. Close to 80% of observations of resting activities in summer were in three CTs, young shrub (34%), mature poplar (25%), and grass shrub (20%). Observations of resting activity in White Spruce and Black Spruce CTs were minimal, while limited use of shrub sapling and spruce willow was observed in late winter and spring. Although substantial use is made of the grass shrub CT for both foraging and resting for all seasons, considerable seasonal use is made of other CTs for both activities.

Elk use of CTs recorded from aerial surveys was tested to determine habitat preference in winter months. Chi-square analysis of each flight indicated that Elk were not utilizing all CTs in proportion to their availability (Table 3). The grass shrub CT was preferred on all but the February 1981 flight, where use was in proportion to availability and 75% of animals observed were resting. Use of the young shrub CT was greater than expected on 70% of the flights. The grass herb CT was used in proportion to availability on half of the surveys, and more than expected on the remainder. Use of the open poplar CT was more than availability on 50% of the surveys as well, with use less than availability indicated only for the April 1981 flight. Preferred use and non use of the shrub sapling CT was equal at 30%, with proportionate use indicated for the remaining 40%. Mature poplar, spruce-willow, White Spruce, and Black Spruce CTs were used less than

TABLE 3. Observed(OBS) and expected(EXP) use of community type(CT) by Elk from winter aerial surveys, 1978-1982, Tuchodi River study area. (+ = significant use, – = significant non use, o = use in proportion to availability, at .10 level)

Survey	November 1978			January 1979			January 1980			March 1980			December 1980			February 1981			March 1981			April 1981			December 1981			March 1982		
	(N=525)			(N=525)			(N=755)			(N=307)			(N=908)			(N=201)			(N=606)			(N=669)			(N=617)			(N=291)		
CT	OBS	EXP	s	OBS	EXP	s	OBS	EXP	s	OBS	EXP	s	OBS	EXP	s	OBS	EXP	s	OBS	EXP	s	OBS	EXP	s	OBS	EXP	s	OBS	EXP	s
	(#'s)			(#'s)			(#'s)			(#'s)			(#'s)			(#'s)			(#'s)			(#'s)			(#'s)			(#'s)		
Grass-herb	41	32	o	93	32	+	61	23	+	6	9	o	54	15	+	8	30	–	6	10	o	62	11	+	13	6	o	21	3	+
Grass-shrub	100	30	+	266	30	+	420	44	+	131	18	+	374	62	+	19	14	o	319	41	+	492	45	+	305	46	+	6	22	o
Young shrub	194	20	+	41	20	+	5	51	–	14	21	o	266	66	+	2	15	–	173	44	+	78	49	+	73	17	+	25	8	+
Shrub-sapling	17	23	–	11	23	–	15	26	–	36	11	+	23	32	o	6	7	–	7	21	–	5	29	–	130	49	+	108	23	+
Open Poplar	18	19	o	23	19	o	154	35	+	10	14	o	66	42	+	60	9	+	50	28	+	18	31	–	39	29	o	35	14	+
Mature Poplar	16	148	–	54	148	–	55	211	–	54	86	–	21	252	–	19	56	–	2	168	–	7	185	–	33	170	–	27	80	–
Spruce-willow	73	134	–	14	134	–	35	193	–	23	79	–	97	232	–	73	51	+	216	155	+	3	171	–	19	158	–	21	74	–
White Spruce	5	48	–	5	48	–	2	67	–	29	27	o	2	81	–	6	18	o	1	54	–	2	60	–	1	55	–	2	26	–
Black Spruce	61	73	o	18	73	–	8	105	–	4	42	–	5	126	–	8	28	–	2	84	–	2	93	–	4	86	–	3	40	–

available for all but three flights. Use of spruce willow was greater than expected for the February 1981 flight, White Spruce was used in proportion to availability for the March 1980 flight, while Black Spruce received proportionate use for the November 1978 survey.

Chi-square analysis of Elk distribution in relation to fire history class indicated that use was not equal to availability on all surveys (Table 4). Preferential use of the 3-7 year FHC, was indicated on all surveys. The 0-2 year FHC was used more than availability on 60% of the surveys, with use less than availability on March 1980 and 1981 flights. Use of the 10-20 year FHC was in proportion to availability on 60% of the surveys, with preference indicated in January and March of 1980, and avoidance in March and April of 1981. Use of the 40, and greater than 100 FHCs were less than availability on all but the March 1980 flight, where use of the greater than 100 FHC was in proportion to availability.

Discussion

Examinations of Elk-fire relationships in the boreal forest are limited. Kelsall et al. (1977) recognized that early post-fire successional stages favored forages used by Elk. Elk numbers increased in Banff and Jasper parks in the 1920s and 1930s in response to numerous wildfires in the early part of the century (Cowan 1947; Flook 1964).

Substantial increases in Elk numbers in northeastern British Columbia within the past fifty years have occurred (Rand 1946; Elliott and Webster 1982, see above). Intentional burning has had considerable impact on the vegetation of the foothill Elk ranges (J. Parminter. 1983. Fire-ecological relationships for the biogeoclimatic zones and subzones of the Fort Nelson Timber Supply Area. Northern Fire Ecology Project, British Columbia Ministry of Forests, Victoria, B.C. 122 pages). This has been linked with an increase and expansion of the Elk herd by Elliott and Webster (1982, 1983, see above) and Seip and Bunnell (1985).

Pellet group surveys in the study area suggest seasonal differences in Elk habitat use, and relative differences in use of habitat between Elk and horses. Seasonal differences in Elk habitat use have been attributed to changes in forage availability, quantity, and quality (Gates and Hudson 1981, 1983; Houston 1982; Irwin and Peek 1983). Slater and Hudson (1980) reported that although Elk and free ranging horses both make considerable use of grassland habitats in the foothills of central Alberta, horse use was considerably more spread out over the other available habitats.

Riney (1957) suggested that pellet group surveys could be used in describe seasonal habitat use by large mammals, although Neff (1968) cautioned against using pellet group data as an index of habitat preference. Collins and Urness (1983) have used

TABLE 4. Observed(OBS) and expected(EXP) use of fire history class(FHC) by Elk from winter aerial surveys, 1978-1982, Tuchodi River study area. (+ = significant use, – = significant non use, o = use in proportion to availability, at 0.10 level) (FHC = range of years since last fire on site)

Survey FHC	November 1978 (N=525) OBS	EXP's (#'s)		January 1979 (N=525) OBS	EXP's (#'s)		January 1980 (N=755) OBS	EXP's (#'s)		March 1980 (N=307) OBS	EXP's (#'s)		December 1980 (N=908) OBS	EXP's (#'s)		February 1981 (N=201) OBS	EXP's (#'s)		March 1981 (N=606) OBS	EXP's (#'s)		April 1981 (N=669) OBS	EXP's (#'s)		December 1981 (N=617) OBS	EXP's (#'s)		March 1982 (N=291) OBS	EXP's (#'s)	
0-2	41	32	o	93	32	+	85	47	+	6	19		59	24	+	8	5	o	6	16	–	62	18	+	20	7	+	26	3	+
3-7	298	51	+	286	51	+	417	72	+	132	29	+	662	121	+	78	27	+	523	26	+	587	89	+	440	93	+	216	44	+
10-20	17	24	o	32	24	o	100	35	+	36	14	+	43	42	o	6	9	o	7	28		6	31		32	28	o	13	13	o
40	164	355		109	355		151	510		104	207		132	612	–	104	135	–	67	407	–	18	451	–	142	414	–	34	196	
99+	5	63		5	63		2	91	–	29	37	o	2	109	–	6	24	–	1	72	–	2	80	–	1	74	–	2	35	–

observations of tame free ranging Elk to show that significant differences exist between pellet group deposition and activity in specific habitats.

Interpretation of ground observation data was hampered by lack of availability measures from which to evaluate preference (Johnson 1980). Visibility difference between community types must be recognized as well, especially during summer with increased foliage density reducing observability in the denser, more closed stands. Comparisons of relative use of habitats by season indicated the importance of younger seral vegetative types of Elk foraging activities. Spring foraging observations were related to Elk searching for new graminoid growth, while summer observations were more spread out over vegetation types. Ground observations revealed a considerable portion of resting activities in the younger types as well, although relative proportions differed seasonally. The limited differentiation of activity patterns from aerial surveys show that time of day affects the type of activity observed, and indicate that resting activities may be occurring in older stands where Elk are not readily visible from ground observation routes.

Elk have a tendency to bed where they have finished feeding, which is often at the edge of a vegetative type (Collins and Urness 1983; Gates and Hudson 1981; Trottier et al. 1983). Midday peaks of resting activity were noted in all seasons by Gates and Hudson (1983). Although there was considerable variability in sites selected for resting in northern Alberta, seasonal extremes in weather were thought to influence the choice of resting habitats (Gates and Hudson 1983).

Aerial surveys of the study area revealed high densities and greater than proportional use of grass and shrub-dominated communities during the winter. Community types on these upland south-facing slopes were characterized by recent fires and relatively low snowfall accumulation. All community types delineated were used by Elk, and on surveys with deep snow (50-60 cm, March, 1981, 1982), increased densities and distributions were observed in the older types. Low Elk numbers recorded for March 1980 and February 1981 flights suggest that Elk were bedded in mature vegetation types and therefore less visible. Proportionate use of Black Spruce vegetation in late fall (November 1978) indicates that this type may have seasonal importance. Winter habitat utilization in the study area appeared to be dictated in a large part by the relative availability of forage as determined by the successional status of vegetation and snow conditions.

Elk have shown preferences for post-fire grass and shrub communities (Rounds 1981). Flook (1964) noted that repeated fire had created grass and shrub communities on arid south-facing slopes in Jasper and Banff parks, and that these areas had been used extensively in the past. He also suggested that high

Elk densities had severely damaged these shrub and grassland ranges. Snow depth and condition are thought to determine Elk distribution primarily by limiting forage. Elk use of grassland habitats does not appear to be restricted by fresh snow up to 20 cm, whereas extensive crusting or depths greater than 30 cm will lead to Elk seeking shrub dominated habitats. Snow depths greater than 60 cm restrict mobility, and will result in extensive use of forested habitats (Martinka 1976; Leege and Hickey 1977; Singer 1979; Gates and Hudson 1981). Crusted snows in late winter restrict Elk use of grassland habitats to periods of the day when solar radiation softens the snow (Gates and Hudson 1981). Highly variable winter Elk habitat use observed for the northern Yellowstone Elk herd over a seven-year period was attributed to changing population size in conjunction with highly variable snow conditions (Houston 1982).

The habitat use patterns of Elk in the study area differ by season and by activity, although extensive use is made of upland grass and shrubland communities throughout the year. These areas are preferred winter habitats if access to forage is not restricted by deep or crusted snow. The consistently high Elk densities observed in grass-shrub community types have the potential to slow successional processes which could lead to site deterioration. As this type currently makes up less than 5% of the study area, expansion of this association by prescribed burning would reduce seasonal densities and disperse Elk distribution. Older community types have importance for their cover values, and for foraging in severe winter periods, and should be maintained within the vegetational mosaic.

Prescribed fire can readily be used to create and maintain Elk range. Burning in the study area in the past has been restricted to dry, upland south and southwest facing slopes that have been relatively easy to burn. Extremely high Elk concentrations on these sites were recorded. In an attempt to disperse Elk densities, future burning prescriptions should be expanded beyond these upland sites. This will involve burning wetter sites, with more difficult prescriptions, and necessitate longer burning seasons. Since Elk use of open habitats can be limited by excessive snowfall accumulations, enhancement plans should incorporate alternative habitats as well as microclimatic considerations.

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Aspects of the Ecology of Wood Turtles, *Clemmys insculpta*, in Wisconsin

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Wood Turtles (*Clemmys insculpta*), were studied in the Black and Wisconsin rivers, Wisconsin, in 1975 and 1988, and 1985 to 1989, respectively. At Black River, mean size of home range of three males ($\bar{x} = 0.25$ ha, SD = 0.165) and six females ($\bar{x} = 0.82$ ha, SD = 0.728) was not significantly different ($t = 1.95$, $P > 0.05$, df = 7). Males moved greater distances per day ($\bar{x} = 41.9$ m, N = 3, SD = 40.53) than did females ($\bar{x} = 27.4$ m, N = 4, SD = 26.32). Most (91.5%) turtles were ≥ 10 years of age. The smallest gravid female was 171 mm carapace length (CL) and the youngest was 14 years of age; the smallest copulating male was 197 mm CL and 20 years of age. Mean clutch size for both BR (SD = 4.24, n = 4) and WR (SD = 4.42, n = 7) was 11 eggs. Cloacal temperatures ($\bar{x} = 23.6$°C, SD = 4.55) were positively correlated ($r = 0.51$, $n = 46$, $P < 0.05$) with ambient air temperatures ($\bar{x} = 23.0$°C, SD = 5.12). At Wisconsin River, of the 24 turtles captured, 8 (33%) were males while 15 (63%) were females. Sex ratios of 1:0.6 and 1:1.9 were calculated for Black and Wisconsin river study sites, respectively. Most (47.5%) captures were in ecotones between alder thickets and grassy openings. Fourteen (93%) of the females were < 200 mm CL, while seven (88%) of the males were ≥ 200 mm CL. Adults used southern wet mesic forest in riverbottom and riparian shrub/forest ecotones.

Key Words: Wood Turtles, *Clemmys insculpta,* ecology, home range, age, sexual dimorphism, Wisconsin.

The Wood Turtle (*Clemmys insculpta*) is a medium-sized semi-aquatic turtle found from Nova Scotia west to Minnesota and south to Virginia (Ernst 1972). It inhabits wooded streams and floodplains along rivers. Although formerly common, habitat destruction and over-collecting have reduced some populations (DeGraaf and Rudis 1981). Previous studies of this species have focused primarily on populations in the eastern range of this species. General ecological data were reported by Allen (1955) and Harding and Bloomer (1979). Movement and habitat use were studied by Carroll and Ehrenfeld (1978), Harding and Bloomer (1979), and Strang (1983), thermal ecology was studied in Pennsylvania by Ernst (1986), and Lovich et al. (1990) studied growth, maturity and sexual dimorphism. Basic ecological data are vital before conservation and management strategies can be applied. This paper presents data on two temporally separate studies using different methods in Wisconsin. The objectives of these studies were to examine population structure, movement and thermal ecology of Wood Turtles in westcentral and northcentral Wisconsin. This paper presents new ecological data on Wood Turtles, but more detailed study of the species' life history is warranted.

Material and Methods

Wood Turtles were captured in two river channel sections along a 16 km length of the Black River (BR) within the Van Loon Wildlife Area (16 km^2) in Trempealeau and La Crosse counties, Wisconsin from June to August 1975 and May 1988. The southern wet mesic forest (Curtis 1959) in this area is dominated by floodplain hardwoods. Sandbars along the river support patchy growths of herbaceous vegetation. Backwater sloughs contain submergent and emergent vegetation; while the river channel has little plant cover. The river flows at about 8-16 km/hr and has a sand substrate. Water level fluctuations of about 1-2 m occurred during the study.

Wood Turtles were captured from 1985-1989 along a 3.2 km by 0.2 km (0.6 km^2) segment of the Wisconsin River (WR) in Vilas County, Wisconsin, in an alder-willow shrub community. The river channel varies from 3-5 m in width and ranges from 0.3 to 1.5 m in depth with a sandy, irregular bottom. The river flows from 0.03-0.06 km/hr and scattered large (0.5 - 1 m in diameter) rocks and logs are present. Six oxbow backwaters form water bodies ranging from shallow emergent wetlands to well-defined ponds with deep muck bottoms. Seasonally high water occurs late April to early May when

runoff from melting snow raises the level about 0.5 m above summer levels for several weeks.

Sampling effort and design differed between WR and BR study areas as follows. Turtles were captured in aquatic habitats by traps (BR only), hand, and dip net. Traps consisted of six fyke nets and three hoop nets (described by Ricker 1958, Vogt 1980). Traps were set for 2-14 days and were often moved depending on trapping success, water levels, and vandalism. Population sampling is biased between study sites due to differences in search effort among habitats and respective vegetation densities, and collection efforts during the nesting season. One river channel at BR was trapped from 26 May to 5 July 1975 and the other from 5 July to 29 July 1975, respectively. Turtles were sampled at WR on 28 visits from 1985 to 1989. Four sampling efforts were conducted at WR in April, 11 in May, 11 in June, and one each in July and August. A mean of 3 hours (range 1.5-4 hours) was spent sampling turtles during each sampling effort at WR. Turtles were mostly collected at exposed grassy areas along the riverbanks at both sites. Cloacal and ambient temperatures (n = 46 of each) were gathered from 15 turtles (13 = WR, 2 = BR) ($\bar{x}$ = 3.1 temperatures/turtle) using a Yellow Springs, Inc., telethermometer. Temperature data at BR were collected from mid- to late-July, 1975. Data at WR were collected from late-April to late-August during 1985-1989.

Data were collected on age, sex and carapace length (CL). Age was estimated by counting plastral growth annuli (Lovich et al. 1990). Since annuli are indistinct after year 19 (*see* Harding and Bloomer 1979), minimum ages were assigned animals $\geq$ 20 years of age. All BR turtles were aged and seven WR gravid females were aged. Turtles were sexed using characters given in Ernst and Barbour (1972). Each individual was given a unique set of carapace notches for future identification (Cagle 1939). Gravid females were identified by palpation of shelled eggs. A sexual dimorphism index (SDI) was calculated for adults using the technique of Gibbons and Lovich (1990) where SDI equals mean size (carapace length) of larger sex divided by the mean size of smaller sex. The result is arbitrarily defined as positive when females are larger and negative when males are larger. Carapace length is used in the index because previous studies have shown that plastron length is an inappropriate measure of sexual size dimorphism (Lovich et al. 1990). Turtle nests at BR were located by observing nesting females or by following turtle tracks to nest sites. Clutch size (CS), egg length, width and weight were recorded for each intact nest.

Radio transmitters weighing $\leq$ 7% of the weight of each turtle were placed on three gravid females at BR and two (183 mm CL, 200 mm CL) non-gravid females at WR. Turtles at BR were tracked from 3 June 1975 to 1 August 1975 with a mean of 20.3 relocations (SD = 3.20) for four females. Three males at BR were located 19 times ($\bar{x}$ = 5.5, SD = 2.12). Home range size was calculated by the minimum polygon method (Mohr 1947). A 185 mm CL female at WR was tracked from 5 July 1985 to 27 September 1985 with 32 relocations and a second female was tracked from 26 April 1986 to 21 June 1986 for a total of 10 relocations. Home range sizes of three males at BR were calculated from hand capture data. These locations were used to determine seasonal home range sizes. The locations of radiotagged turtles were determined by triangulation of two or more locations and these locations placed on a map of known scale.

Results

Fifty-eight turtles (20 males, 37 females, and one juvenile) were captured at BR and 34 (58.6%) were recaptured. Thirty-one (84%) of the turtles were hand captured on one nesting area thus biasing the data. These individuals (4 males, 27 females) were excluded from sex ratio calculations. Twenty-four turtles were captured at WR. Eight (33%) were males and 15 (63%) were females. The sex ratios at BR and WR were 1:0.6 and 1:1.9, respectively. Age class distribution at BR consisted primarily of individuals $\geq$ 10 years of age (91.5%, Table 1). Mean carapace length (CL) for turtles $\geq$ 10 years of age at both sites was 200.9 mm for males (n = 28) and 187.0 mm for females (n = 48), resulting in an SDI of −1.07. Overall, the largest individual was a 225 mm CL male from WR. Thirty-nine individuals (67.3%) were between 180 mm CL and 200 mm CL. Sixty-one percent (n = 17) of

TABLE 1. Age class distribution of Wood Turtles, Black River Study Area.

Age (Years)	Number of Turtles			
	Juvenile	Male	Female	Total (%)
< 5	1	--	---	1 (1.7)
5-9		1	3	4 (6.8)
10-14	-	6	3	9 (15.6)
15-19		5	22	27 (46.6)
> 19		8	9	17 (29.3)
Total	1	20	37	58 (100.0)

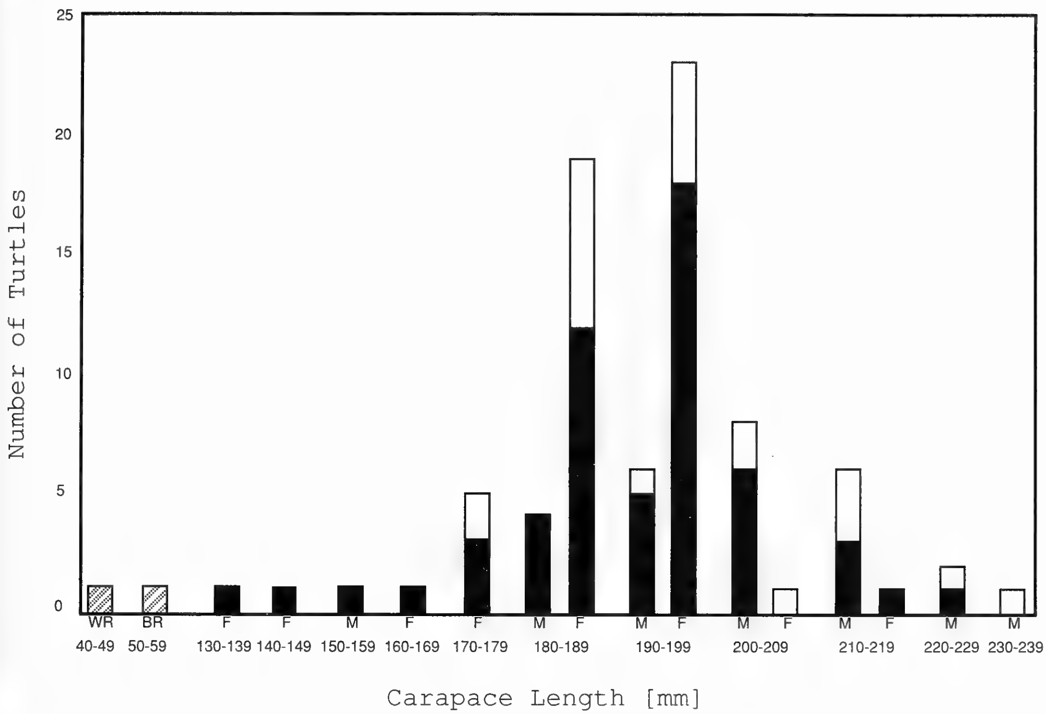

FIGURE 1. Size class (carapace length) distribution of 81 Wood Turtles from Black River (BR) and Wisconsin River (WR) study areas. Black bars indicate BR turtles, white bars indicate WR turtles, and striped bars are juvenile turtles. M and F indicate male and female, respectively.

the males were ≥ 200 mm CL and 96% (N = 50) of the females were ≤ 200 mm CL (Figure 1).

The minimum size at maturity, based on the size of the smallest gravid female, was 171 mm CL ($\bar{x}$ = 188.0 mm CL, n = 38, SD = 6.40). The three males observed in coition or mounted atop females were 180 mm CL, 197 mm CL and 209 mm CL. The smallest identifiable male was 150 mm CL. The youngest gravid female and copulating male of known ages were 14 ($\bar{x}$ = 17.4 years, SD = 2.42) and 20 years of age, respectively. Three females (two 183 mm CL [18 years] and one 190 mm CL [18 years], respectively) were gravid during two consecutive years while one 196 mm CL (20 years) female was gravid in two nonconsecutive years. She was not known to be gravid in the intervening year. During May 1988, a marked 195 mm CL female, at least 20 years of age in 1975, was recaptured at Black River (R. Hay, personal communication). This animal was a minimum of 33 years of age in 1988. The oldest known wild Wood Turtle previously reported was a minimum of 28 years (Harding and Bloomer 1979).

The minimum daily movement of (MDM) of three males at BR ($\bar{x}$ = 41.9 m, SD = 40.53) was significantly longer than the MDM of four gravid females ($\bar{x}$ = 27.4 m, SD = 26.32) (t = 1.41, $P < 0.01$, df = 87), as determined during the period of 3 June 1975 to 1 August 1975. The home ranges of three males ($\bar{x}$ = 0.25 ha, SD = 0.165) at BR were not significantly different from that of four females ($\bar{x}$ = 0.54 ha, SD = 0.330). Males had home ranges from 0.08 ha to 0.41 ha while that of females ranged from 0.27 ha to 0.91 ha in size. The home ranges of the 185 mm CL and 200 mm females at WR were 2.2 ha and 0.6 ha, respectively.

Cloacal temperatures were positively correlated (r = 0.51, n = 46, $P < 0.05$) with air temperatures, as expected for an ectotherm. Forty-six cloacal temperatures of 15 turtles (2 = BR, 13 = WR) ranged from 11.9°C to 31.5°C ($\bar{x}$ = 23.6°C, SD = 4.55) while corresponding environmental (air) temperatures ranged from 18.0°C to 36.0°C ($\bar{x}$ = 23.0°C, SD = 5.12). Two females at BR were found in the river on seven (15.6%) occasions (total locations = 45). One of these females used the river 100% of the time during daily air temperatures of 26°C – 35°C.

Discussion

The present study noted an abundance of older individuals. Younger age classes are either scarce or

may use different habitats than adults. In Michigan, the average age for both sexes was > 20 years (Harding and Bloomer 1979). In Pennsylvania a large proportion of the population was > 20 years of age (Lovich et al. 1990). In New Jersey, 45.5% of the adult population was > 140 mm CL; the adult sex ratio was 1:1 (Farrell and Graham 1991). The carapace length of nesting females in Wisconsin is larger than that reported in other areas (Lovich et al. 1990) although the age of the smallest nesting females in our study was similar to age at sexual maturation reported in other studies (Harding and Bloomer 1979; Lovich et al. 1990). The age at maturity is identical to that reported by Farrell and Graham (1991).

Clutch size (CS) appears to vary with mean female body size. The mean female CL in this study was 187 mm ($\bar{x}$ CS = 11, N = 11) while that in Michigan and New Jersey was 182 mm ($\bar{x}$ CS = 10.4, N = not given) and 165 mm ($\bar{x}$ CS = 8, N = not given), respectively (Harding and Bloomer 1979). The mean adult female CL in a New Jersey population was 170.9 mm ($\bar{x}$ CS = 8.5, N = 21) (Farrell and Graham 1991), while that in northern Virginia was 186.1 mm ($\bar{x}$ CS = 9.9, N = 10; J. F. McBreen, personal communication). The size of females associated with individual nests is unknown. Females may be optimizing energy use as larger females may be alloting more energy into increased clutch sizes. Other studies have suggested this correlation (Gibbons et al. 1982; Congdon et al. 1983).

Our minimum daily movement data are indicative of the restricted distances this species travels. In Pennsylvania, Strang (1983) found a mean daily minimum travel distance of 139 m ($\pm$ 81 m SD). Our home range sizes were small and limited to wooded, riverine habitat. That the males travelled greater daily distances than did females while the females had large home range sizes may be an artifact of short-term sampling. Other researchers have also reported small home range sizes and limited movements (Ernst 1968; Strang 1983). In fact, Harding and Bloomer (1979) found 63.8% (N = 30) of their recaptured turtles were within 150 m of the original point of capture.

Our thermal biology data indicate that this species selects environmental temperatures in the middle of its activity range and not near its critical thermal maximum. Ernst (1986) and Farrell and Graham (1991) reached similar conclusions. Turtles in this study apparently seek shelter prior to the onset of environmental temperatures close to critical levels, as do other reptiles (Gregory 1982; Ultsch 1989). Our highest recorded cloacal temperature of 31.5°C, similar to that of 30.1°C found by Ernst (1986), does not approach the mean critical thermal maximum of 41.3°C recorded in the laboratory by Hutchison et al. (1966). Farrell and Graham (1991) found that cloacal temperatures of Wood Turtles are closely correlated with substrate temperature. They found a correlation of r = 0.62 for basking individuals (N = 264) and a maximum recorded cloacal temperature of 31.0°C. North temperate reptiles are well-adapted to lower temperatures (Aleksiuk 1971a,b) and perhaps Wood Turtles select lower temperature regimes. The mean difference in air temperature relative to body temperature is –0.56°C (SD = 4.841). The significance of cloacal temperatures below that of the ambient air temperature cannot be interpreted without knowing the ambient temperature regime prior to the time cloacal temperatures were obtained.

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New Records of Freshwater Leeches (Annelida: Hirudinea) from Quebec

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Ricciardi, Anthony, and David J. Lewis. 1991. New records of freshwater leeches (Annelida: Hirudinea) from Quebec. Canadian Field-Naturalist 105 (3): 368–371.

Seven species of freshwater leeches (Annelida: Hirudinea), collected in the vicinity of the Island of Montreal, are added to the list of Quebec fauna, including two species (*Cystobranchus meyeri* and *Mooreobdella tetragon*) which are reported from Canada for the first time.

Key Words: Hirudinea, leeches, new records, distribution, Quebec, Canada.

Sept espèces de sangsues d'eau douce, recoltés près de Montréal, sont signalées pour la première fois au Québec, incluant deux espèces (*Cystrobranchus meyeri* et *Mooreobdella tetragon*) qui sont mentionnées pour la première fois au Canada.

Mots Clés: Hirudinea, sangsues, premières mentions, distribution, Québec, Canada.

Freshwater leeches are represented in Canada by four families and at least 40 species (Davies 1971; Madill 1985). A total of 26 species have been collected in Quebec (Moore 1922; Meyer 1937; Meyer and Moore 1954; Davies 1973; Vincent and Vaillancourt 1977, 1980). Davies (1973) noted that the number of leech species recorded from a province or territory in Canada reflected the number of sites and specimens examined. Many of the species considered to be rare, or thought to have limited distributions, may actually be widely distributed. This paper adds seven species to the list of Quebec fauna, including two species which are recorded in Canada for the first time.

Study Area and Methods

The collections come from the lower Ottawa River, the St. Lawrence River, and Lake St-Louis (at the confluence of the two rivers) near the Island of Montréal (45°27'N, 73°57'W), and from two ponds in Ste-Anne-de-Bellevue, Quebec. Many of the specimens were taken from Lake St-Louis and the St. Lawrence River between 1980 and 1982 as part of larger benthic collections made with an Ekman grab (Lewis, unpublished data). Additional specimens collected (by Ricciardi) in 1989 and in the spring of 1990, came from the Ste-Anne Rapids of the lower Ottawa River, at the southwestern tip of the Island of Montréal.

The specimens were preserved in 70% ethanol. Prior to preservation, specimens collected in 1989 and 1990 were narcotized by the following method adapted from Mann (1961) : 70% ethanol was dripped from a pipette into water in a petri dish containing the leeches, gradually over a period of 20–30 minutes, until they were no longer moving.

In total, 350 leeches were examined. Identifications were made using the keys provided by Davies (1971) and Klemm (1985). Several specimens of each of the species listed here were reviewed by Dr. Ronald W. Davies, of the University of Calgary, who confirmed their identification; they were subsequently deposited in the Canadian Museum of Nature (Ottawa, Canada).

List of Species

Family PISCICOLIDAE

Cystobranchus verrilli Meyer 1940

Twelve specimens of *C. verrilli* were found in an aggregation on the underside of a rock in 20 cm of water (temperature 14°C) on 24 May 1989, in a shallow riffle of the Ste-Anne Rapids. In Canada, *C. verrilli* has been reported from Ontario (Meyer and Moore 1954) and Alberta (Leong and Holmes 1981). In the United States, it has been reported from Arkansas, Illinois, Iowa, and West Virginia (Klemm 1985). *Cystobranchus verrilli* has been found to be parasitic on Burbot (*Lota lota* (Linnaeus)), Channel Catfish (*Ictalurus punctatus* (Rafinèsque)), Smallmouth Bass (*Micropterus dolomieui* Lacépède), Bluegill (*Lepomis macrochirus* Rafinèsque) and Walleye (*Stizostedion vitreum* (Mitchell)) (Hayunga and Grey 1976), all of which occur in the vicinity of the Island of Montréal.

Cystobranchus meyeri Hayunga and Grey 1976

One specimen of *C. meyeri* was collected on 14 June 1989, from a substrate of sand and coarse gravel using a Surber sampler, in the same location as *C. verrilli* (water temperature 17°C). Twenty-five additional specimens were collected by hand near this location, on 14 May 1990, in shallow water (depth <60 cm) in a perpetually shaded area underneath a bridge. At the time of collection, the current was slow (0.40 m/s) and the water temperature was 12°C. All of these leeches were found in the sediment (sand, silt and rubble), attached to the under-

side of partially buried rocks. Using a square quadrat frame (929 cm^2), population densities were estimated from the mean of five random samples. Within the shaded area, the population of *C. meyeri* reached a density of about 65 individuals/m^2. No leeches were found outside the shaded area. Several additional specimens were collected from the underside of rocks along the north shore of Lake St-Louis near the Lachine Rapids, on 17 June 1990, in a water temperature of 17°C.

This is the first record of *C. meyeri* in Canada; it was previously known only from New York and Maryland (Klemm 1985). In the Mohawk River in eastern New York, Hayunga and Grey (1976) found it on the fins of the White Sucker *Catostomus commersoni* (Lacépède) when the fish were spawning. Klemm (1982) examined specimens from the fins of *C. commersoni* from southeastern Lake Ontario. White Suckers and Walleyes are frequently observed in the Ste-Anne Rapids in early spring, ovipositing in the same riffle area where both *C. meyeri* and *C. verrilli* were collected. The leeches may have left their hosts in late winter or early spring, as do most piscicolids and glossiphoniids during their breeding season (Sawyer and Hammond 1973), and attached to the rocks from which they were later collected. It has been suggested that *C. meyeri* may commonly spend periods of time isolated from a host (Hayunga and Grey 1976).

Myzobdella lugubris Leidy 1851

Three specimens of *M. lugubris* were identified from the benthos collected from Lake St-Louis in the summers of 1980 and 1981; three additional specimens were identified from samples taken from the St. Lawrence River, near Ile Perrot, Quebec, in the summer of 1982. *Myzobdella lugubris* has been reported in Canada from New Brunswick (Appy and Dadswell 1981), Ontario (Meyer 1946; Meyer and Moore 1954), Manitoba (Davies 1973), Saskatchewan (Meyer 1946; Oliver 1958; Reed 1962), and Alberta (Moore 1964; Davies 1973). In the United States, *M. lugubris* is common and widely distributed (Klemm (1985)). Davies (1973) lists several host species, most of which occur in the vicinity of the Island of Montrèal.

Primarily a brackish water species, *M. lugubris* was previously considered distinct from the anatomically similar freshwater species *M. (=Illinobdella) moorei* (Meyer 1940); the distinction was apparently only on the basis of their habitats. For this reason, Sawyer et al. (1975) considered these two forms to be synonymous, with *M. lugubris* Leidy as the senior synonym. However, the authors further listed all *Illinobdella* species (*I. alba* Meyer 1940, *I. elongata* Meyer 1940, *I. richardsoni* Meyer 1940 and *I. moorei* Meyer 1940) as junior synonyms of *Myzobdella lugubris*, without providing an explanation for these taxonomic changes. Until such an explanation is provided, we believe that it is necessary to distinguish the genera *Myzobdella* and *Illinobdella* to avoid obscuring possible taxonomic evidence. Our specimens correspond with *Myzobdella lugubris* as described (as *M. moorei*) by Davies (1971): the body is without pulsatile vesicles, and is divided into distinct trachelosomal and urosomal regions; one pair of eyes is present; the posterior sucker is narrower than the body and is reduced to a concavity of the posterior body.

Piscicolaria reducta Meyer 1940

Three specimens of *P. reducta* were taken from Lake St-Louis benthos in the summers of 1980 and 1982. This species has been reported throughout the eastern United States, from Florida to Maine. In Canada, it has been reported only from Ontario (Klemm 1972), and it appears to be common in the Great Lakes region (Klemm 1985). It has been reported as parasitic on a variety of fishes (Erickson 1976; Nagel 1976; Murray et al. 1977), of which only the Channel Catfish (*I. punctatus*) occurs in Lake St-Louis.

Family GLOSSIPHONIIDAE

Actinobdella inequiannulata Moore 1901

Four specimens of *A. inequiannulata* were collected from a weedbed in Lake St.Louis in the summer of 1982, and one additional specimen was collected from the St. Lawrence River near Ile Perrot. This species, reported also under its synonym *Actinobdella triannulata* (Daniels and Freeman 1976), has a wide distribution in North America (Klemm 1985), but is infrequently encountered. In Canada, it has been recorded from Ontario (Moore 1924; Daniels and Freeman 1976; and others), Saskatchewan (Reed 1962) and British Columbia (Bangham and Adams 1954), and has been found parasitic on the White Sucker (*C. commersoni*), Longnose Sucker (*C. catostomus* (Forster)) (Daniels and Freeman 1976), Largescale Sucker (*C. macrocheilus* Girard) (Bangham and Adams 1954) and the Snapping Turtle (*Chelydra serpentina*) (Moore 1924). With the exception of the Largescale Sucker, all of these species occur in the vicinity of the Island of Montréal.

Placobdella parasitica (Say 1824)

Several specimens of *P. parasitica* were removed from Snapping Turtles (*Chelydra serpentina serpentina* Linnaeus), and Painted Turtles (*Chrysemys picta marginata* Agassiz), in April, 1990; the turtles were collected by J. Roger Bider from two small ponds located in Ste-Anne-de-Bellevue, on the western tip of the Island of Montréal. The leeches were found attached to the turtles' limbs and axillary regions. Most of the individual leeches were brooding young (borne in a cluster on their ventral side). Brooding adults varied between 40-65 mm in length. The specimens were easily identified by the pres-

ence of several dark green longitudinal stripes on the venter; dorsal pigmentation was variable. Several additional specimens of *P. parasitica* were removed from Wood Turtles (*Clemmys insculpta* LeConte) collected by J. R. Bider from the Yamaska River in southwestern Québec.

Placobdella parasitica is the most commonly encountered leech on turtles in Canada and the northern United States (Sawyer 1972), and has been reported in Canada from Nova Scotia (Pawlowski, 1948; Leblanc and McClung 1979), Ontario (Moore, 1922; and others); Manitoba (Moore 1898), Saskatchewan (Rawson and Moore 1944; Oliver 1958; MacCulloch 1981), and Alberta (Moore 1964).

Family ERPOBDELLIDAE

Mooreobdella tetragon Sawyer and Shelley 1976

Ten specimens of *M. tetragon* were identified from preserved Lake St-Louis weedbed collections made in the summers of 1980, 1981 and 1982. This species is reported from Canada for the first time. Previously, *M. tetragon* was known only from the Atlantic Coast and Gulf States of the United States (Florida, Alabama, Georgia, South Carolina, North Carolina, New Jersey and Massachusetts) (Klemm 1982).

Other *Mooreobdella* species collected from Lake St-Louis were *M. microstoma* (Moore 1901) and *M. fervida* (Verrill 1871). Vincent and Vaillancourt (1980) collected *M. microstoma*, *M. fervida*, and *M. melanostoma* (Sawyer and Shelley 1976), all from one area in the St. Lawrence River, and thus found that *Mooreobdella* species cannot be distinguished by their geographic location as suggested by Sawyer and Shelley (1976). Our data adds to the evidence that the distributions of *Mooreobdella* species overlap, although the extent of this overlap remains to be determined.

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Common Loon, *Gavia immer*, Brood Habitat Use in Northern Wisconsin

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We investigated 23 Common Loon (*Gavia immer*) territories on a 5798-ha impoundment in northern Wisconsin during 1986 and 1987 to characterize brood habitat use. Total brood period: TBP (1-42 days post-hatch), areas: (x = 56.0 ha), and early brood period: EBP (1-14 days post-hatch), areas (x = 11.5 ha) were larger than reported elsewhere; while average between year spatial overlap of TBP areas (46%) was less. Mean water depth was significantly lower ($P < 0.01$) in EBP areas. Percent frequency of occurrence and composite stem density of vegetation was greater in EBP areas. Areas of greater vegetation density were used to rear broods during 1986. Annual water level fluctuations may cause loons to utilize suboptimal habitat.

Key Words: Common Loon, *Gavia immer*, brood habitat use, impoundments, Wisconsin.

Proper brood rearing habitat is integral to Common Loon (*Gavia immer*) reproductive success. Subsequent reuse of this habitat should be influenced by natural selection if habitat use is correlated with reproductive success (Strong et al. 1987). Sutcliffe (1980) and Yonge (1981) found little variation in Common Loon breeding territories used in consecutive years.

McIntyre (1983) described brood rearing habitat of loon chicks ≤2 weeks old as shallow, protected areas adjacent to shore that generally contained abundant aquatic vegetation. Strong et al. (1987) quantified brood areas for chicks ≤6 weeks old and found 57–86% year-to-year spatial overlap. Our objectives were to: (1) quantify size and between-year spatial overlap of brood areas and; (2) describe aquatic vegetation and physical characteristics.

Study Area and Methods

The study was conducted on the Turtle-Flambeau Flowage (TFF), a 5798-ha impoundment in northern Wisconsin. The TFF was inundated in 1926. The TFF is shallow with approximately 50% of the total area <3 m in depth; maximum depth is 16 m. The TFF has 2575 ha of adjoining wetland, >150 islands, 290 km of shoreline, and a shoreline development factor (Hutchinson 1967) of 12.91. Water levels generally drop 65–100 cm between May and August. Summer homes and resorts occupy <5% of mainland shoreline. Predominant recreational use within the TFF includes fishing and camping, with greatest activity occurring adjacent to human residences.

The TFF was surveyed by boat from late-April through July 1986, and from May through July 1987 to locate territorial pairs and nest sites (Belant and Anderson 1991). Brood observations and habitat data were grouped temporarily into early brood period (EBP = 1–14 days post-hatch), late brood period (LBP = 15–42 days post-hatch), and total brood period (TBP = 1–42 days post-hatch). From 1–14 days, chicks are in almost constant association with adults (McIntyre 1983). Observations on each brood were conducted at least weekly for one or three hour periods. Visual locations were obtained every three minutes using a compass bearing from a known point and estimating the distance between the loon and shore or observer. Locations were recorded on 1:24 000 scale USGS topographic maps. Observations were continued until chicks were six weeks old. A minimum of 40, 80, and 120 points was used to establish the extent of EBP, LBP, and TBP, respectively. Brood areas were mapped by plotting locations on aerial photographs gridded into 1-ha cells. Brood areas included all 1-ha cells in which chicks were observed and adjacent unused cells flanked on 3–4 sides by used cells and/or land (Strong 1985). Cells partially composed of land were measured to the nearest 0.1 ha. A weighted similarity index (Sorenson 1948; Strong et al. 1987) was used to determine spatial overlap of brood areas between years. Fifty and 30 representative locations during 1986 and 1987, respectively, within each EBP and LBP area were inventoried for water depth, vegetation, and woody debris. Vegetation samples were obtained by grapple hook. Vegetation at each location was identified to the genus level and composite stem density measured. Vegetation stem density classes were visually estimated as class 1 (≤5 stems), 2 (>5 but <15 stems), or 3 (>15 stems). Secchi disc readings were taken every 10th sample to measure water clarity. Water samples were collected during 1986 and estimates of pH, alkalinity, and specific conductance obtained.

TABLE 1. Size (ha) and yearly spatial overlap of EBP (early brood period), LBP (late brood period), and TBP (total brood period) areas for seven Common Loon territories, Turtle-Flambeau Flowage, Wisconsin 1986-1987.

	EBP			LBP			TBP		
Territory	1986	1987	% overlap*	1986	1987	% overlap	1986	1987	% overlap
1	15.3	15.0	0	49.3	48.5	65	53.1	62.8	56
2	11.9	13.8	0	61.8	58.7	59	65.9	80.0	54
3	6.2	13.1	17	45.0	41.3	51	47.3	41.7	40
4	13.1	9.2	0	47.1	82.2	26	58.6	82.9	24
5	8.4	10.3	83	46.6	57.9	62	55.4	61.1	70
6	10.6	12.3	0	32.4	57.3	24	43.7	61.9	23
7	12.0	10.8	0	54.2	62.7	63	64.1	70.5	57
Average	11.1	12.1	14	48.1	58.4	50	55.4	65.8	46

*% overlap = 100 X 2C/(A + B), where A and B are the yearly brood areas and C is the area shared by A and B.

Results and Discussion

Loons reared 13 and 12 broods ($n = 22$ and 23 territorial pairs) in 1986 and 1987, respectively. Average TBP, EBP, and LBP areas for all broods were 56.3 ha (SD ± 12.5), 11.5 ha (SD ± 4.7), and 50.1 ha (SD ± 12.4), respectively. EBP areas were 3.5× larger than equivalent "nurseries" in Saskatchewan (McIntyre 1983). TBP areas were 38% larger than those reported in Maine (Strong et al. 1987). Territorial Common Loon density on the TFF was lower (Belant and Anderson 1991) than densities reported in other studies of brood habitat (McIntyre 1983; Strong et al. 1987). Larger brood area size could reflect lower quality habitat. Conversely, Common Loon density may effect territory size and subsequently effect the subparts of a territory.

Pairs with broods in both years did not have significantly different TBP areas (paired *t*-test; $P = 0.12$, $n = 7$), LBP areas (paired *t*-test; $P = 0.11$, $n = 7$), or EBP areas (paired *t*-test; $P = 0.48$, $n = 7$) in 1987 than in 1986 (Table 1). The lack of significance may be attributable to small sample sizes. Average overlap of TBP and LBP areas between years was 46% and 50%, respectively. No overlap of EBP areas was found in five of seven instances. Strong et al. (1987) reported a between-year mean overlap of 69% for brood areas in Maine. Lower between-year mean overlap during this study was attributed to 50- to 60-cm lower water levels during 1987, which eliminated portions of previous brood areas. Remaining portions of EBP areas unoccupied in 1987 that were occupied in 1986 may have become unattractive due to shallow water and extremely dense vegetation growth. The two instances where partial overlap of EBP areas occurred between years were in deep water (>3 m in 1986) with rocky substrate and sparse vegetation. Annual water level variations during the brood-rearing period may create unsuitable former brood habitat, forcing returning loons to select different areas. Fledging success was lower in 1987 than in 1986 (Belant and Anderson 1991), which may imply that brood-rearing areas selected during 1987 were less suitable.

All EBP areas were adjacent to shore and appeared physically sheltered from intensive wave action. These characteristics of EBP areas are supported by McIntyre (1983) and Strong (1985) who suggested that sheltered areas are an important component of brood habitat. Seventy-six percent of EBP areas were defined by the physical boundaries of bays in which the EBP area occurred.

Three (12%) broods used the area adjacent to the nest during EBP. Six (24%) broods used the area adjacent to the nest for three to six days before moving to an adjacent bay. Sixteen (64%) broods left the nest area immediately after hatching; mean distance from nest to center of EBP areas was 684 m. Mean distance from nest to center of TBP areas for all broods was 763 m. McIntyre (1983) suggested that adults may move their young to assist in imprinting, to remove their young from a possible predator

TABLE 2. Percent frequency of occurrence of vegetation and woody debris in EBP (early brood period) and LBP (late brood period) areas, Turtle-Flambeau Flowage, Wisconsin 1986-1987.

Species	EBP	LBP
Myriophyllum spp.	20.8	22.0
Utricularia spp.	6.4	17.6
Potamogeton spp.	10.8	4.9
Elodea spp.	10.0	2.8
Chara spp.	4.7	1.1
Nitella spp.	2.2	2.6
Ceratophyllum spp.	0.9	0.3
Nymphaea spp.	0.9	0.1
Najas spp.	0.9	0.0
Sparganium spp.	0.8	0.0
Hyperaceae spp.	0.5	0.1
Sagittaria spp.	0.2	0.2
Vallisneria spp.	0.1	0.2
Nuphar spp.	0.0	0.1
Woody Debris	30.4	22.0

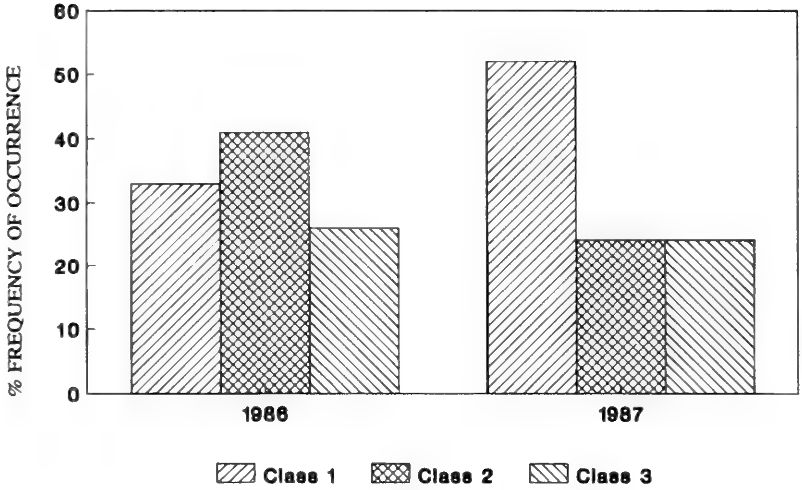

FIGURE 1. Percent frequency of occurrence of composite vegetation stem density classes 1 (≤5 stems), 2 (>5 but ≤15 stems), and 3 (>15 stems) for 23 Common Loon broods, Turtle-Flambeau Flowage, Wisconsin, 1986-1987.

located site, and because habitat selection is dissimilar for nesting and brood rearing.

Mean pH (7.65), specific conductance (67.9 umhos), and alkalinity (30.3) were similar to levels reported by Zimmer (1979) for lakes with nesting adults. Water clarity did not appear to limit adult foraging efficiency, averaging 163 cm for all areas in both years. Barr (1973) stated loon foraging efficiency decreased if visibility was <1.5 m. High visibility in relatively shallow water may provide increased foraging success by Common Loons.

Mean water depth was significantly greater (*t*-test; $P = 0.001$, $n = 1980$) in LBP ($\bar{x} = 217$ cm) areas than in EBP ($\bar{x} = 187$ cm) areas. Similar mean water depths were reported for EBP areas (McIntyre 1983) and TBP areas (Strong 1985). These water depths probably provide optimum foraging opportunities. Yellow Perch (*Perca flavescens*) and other small fish are common on the TFF (Lealos and Bever 1972). Most small fish in lakes prefer shallow water (Scott and Crossman 1973). Thus, it would be advantageous for loons to use shallow water areas for brood rearing and foraging.

Loons used areas containing a higher percent frequency of occurrence of vegetation and woody debris during EBP (54%) than during LBP (40%) for both years. Dominant vegetation found in EBP and LBP areas included *Myriophyllum* spp., *Utricularia* spp., *Potamogeton* spp., and *Elodea* spp. (Table 2). Brood areas containing aquatic plants, particularly those with high leaf dissection (eg. *Myriophyllum* spp. and *Utricularia* spp.) could potentially support more fish and fish prey items, making these areas more suitable to Common Loons (Krecker 1939; Andrews and Hasler 1943; Rosine 1955; Mrachek 1966; Biochino and Biochino 1979).

Areas of greater vegetation density were used to rear broods during 1986 (Figure 1). Although non-brood rearing areas were not quantified, loons appeared to select sheltered areas with high vegetation density to rear broods. Aquatic vegetation is sparse throughout most of the TFF (Andrews and Threinen 1970), and sheltered sites with high aquatic vegetation density appear limited. Larger brood areas observed during 1987 may be explained in part by lower vegetation densities, which probably support a lower prey base. Aquatic vegetation appears to be an important component of Common Loon brood habitat by providing habitat and forage for prey species.

In conclusion, Common Loon habitat management should incorporate protection of known brood rearing areas. Additionally, alternative areas with suitable brood rearing characteristics should be delineated and protected, particularly on impoundments with high annual water level variation. Annual water level variations on impoundments should be minimized during brood rearing to allow reuse of optimal brood areas and minimize site loss.

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Rare and Disjunct Plants from Whitemud Falls Ecological Reserve, Northeastern Alberta

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Whitemud Falls Ecological Reserve, located in northeastern Alberta, includes at least six distinct habitats that support a diverse flora; one hundred and ninety-eight vascular plant species (49 families), 57 mosses (24 families), four hepatics (three families) and 35 lichens (seven families) have been recorded to date. Sixteen vascular and six non-vascular plant species present in the area are rare or disjunct in Alberta, and are described with reference to geographic distribution and habitat occurrence within the Reserve.

Key Words: Conservation, environmentally significant areas, plants, range extensions, disjunct species, phytogeography, floristics, Alberta, Canada.

Twelve Ecological Reserves have been established in Alberta in order to preserve representative examples of major provincial ecosystems. Field surveys of these reserves have led to numerous significant records of both vascular and non-vascular plants. This paper discusses several notable records for the Whitemud Falls Ecological Reserve.

Study Area

Whitemud Falls Ecological Reserve was established in 1987 to preserve several ecosystems considered typical of the mixedwood boreal forest in Alberta, and to protect unique geologic and botanical features. The Reserve is located approximately 80 km due east of Fort McMurray, Alberta (56°41'N, 110°05'E; see Figure 1) and is about 900 ha in area. It lies entirely within the confines of the Clearwater River valley. There is no road access to the Reserve, but the river is a popular and historically significant canoe travel route.

The Reserve lies within the Subhumid Low Boreal Ecoclimatic Region, which is characterized by warm summers and cold, snowy winters (Ecoregions Working Group 1989). Aspen-dominated forests on moderately moist sites are typical of this region in Alberta (Strong and Leggat 1981), but within the Reserve Jackpine and aspen communities on dry, sandy soils are most common (Downing and Legris 1987).

Physical and chemical weathering of Devonian dolomites underlying the Reserve has promoted development of karst features (Carrigy 1959; Ozoray 1974). The Clearwater River has likely been a major influence on the development of bedrock features such as caves and rock stacks, which are rare in northern Alberta. Whitemud Falls is itself unusual; waterfalls are uncommon in Alberta east of the foothills and south of the Canadian Shield. Sandy fluvial and eolian deposits bedrock are present mantling over much of the Reserve. Small wetland areas and intermittent streams occur locally along the valley floor.

Methods

Field surveys conducted over a ten-day period in July 1987 were directed toward the collection of basic ecological data. Vegetation inventories were one component of the survey and focussed on both description of terrestrial vegetation communities within the Reserve and preparation of a comprehensive floral list. Sampling involved the collection of data at intervals along foot traverses throughout the Reserve. These traverses were run across areas of high landscape diversity as determined by preliminary airphoto interpretation of landscape features (vegetation, topography, geomorphology, hydrology) to maximize sampling efficiency. Aquatic environments were not sampled. Vegetation data analysis employed the Braun-Blanquet tabular method (Mueller-Dombois and Ellenberg 1974). Inventory results are reported in Downing and Legris (1987); an abbreviated description of community types and associated environmental conditions is provided below.

Results and Discussion

Table 1 summarizes the rare and disjunct vascular and non-vascular flora known to occur within the Reserve and their associated habitats. Brief habitat descriptions and phytogeographic information for each of the species is provided below.

(1) *Terrestrial habitats within the Reserve*

At least five distinct habitats which support one or more species of rare or disjunct flora occur within the Reserve.

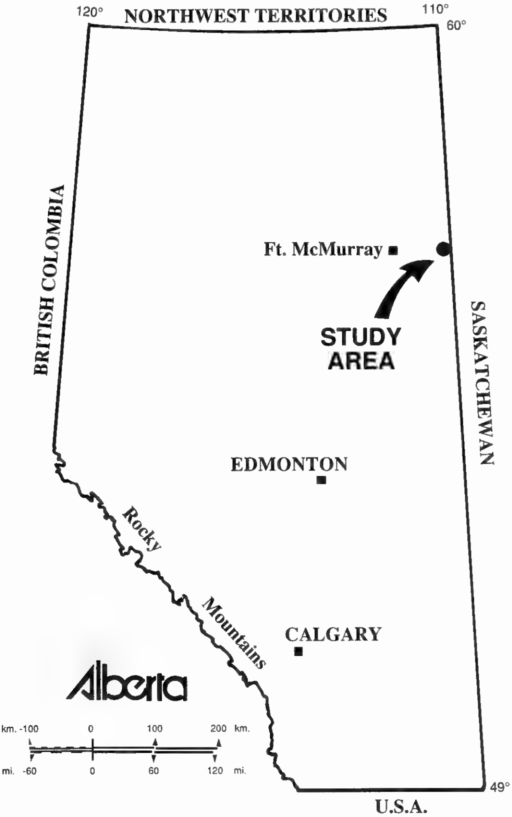

FIGURE 1. Location of Whitemud Falls Ecological Reserve "Study Area" in Alberta.

(a) *Erosional bedrock features.* Rock exposures, cliffs and gullies adjacent to the Clearwater River provide a variety of microsites. Extremely dry rock faces are dominated by crustose lichens and drought-tolerant mosses, with a variety of vascular and non-vascular species in slightly moister environments, i.e. rock crevices or rock ledges. Deep gullies between bedrock exposures provide moist, cool conditions under which many boreal species flourish. Stunted Jackpine (*Pinus banksiana* Lamb) forests with a Bearberry (*Arctostaphylos uva-ursi* (L.) Spreng.) dominated understory are characteristic of very shallow sandy Brunisolic soils overlying bedrock. Limestone bedrock probably exerts a controlling influence on soil and water chemistry.

(b) *Dry sand plains and dunes.* Jackpine communities with an understory characterized by Bearberry and lichens (*Cladina* spp.) occur on rapidly drained, mainly south or west facing sites. Green Alder (*Alnus crispa* (Ait.) Pursh), Bunchberry (*Cornus canadensis* L.) and Feathermoss (*Pleurozium schreberi* (Brid.) Mitt.) are understory associates on moister sites (usually north and east facing slopes).

(c) *Sandy veneers and blankets mantling bedrock.* Dry aspen (*Populus tremuloides* Michx.) communities with an understory dominated by Bearberry, Prickly Rose and Wild Rose (*Rosa acicularis* Lindl., *R. woodsii* Lindl.) occur on rapidly to well drained thick sand blankets. These sites are not as dry as those occupied by Jackpine/Bearberry/lichen communities on habitats (a) and (b).

(d) *Wet, poorly drained depressions, often with organic deposits over mineral soils.* Two community types are common in this habitat: shrub-herb communities dominated by willows (*Salix* spp.), River alder (*Alnus tenuifolia* Nutt.), Marsh Reed Grass (*Calamagrostis canadensis* (Michx.) Beauv.) and sedges (*Carex* spp.); and Black Spruce (*Picea mariana* (Mill.) BSP.) communities, with an understory characterized by Labrador Tea (*Ledum groenlandicum* Oeder) and sphagnum mosses (*Sphagnum* spp.).

(e) *Wet mudflats, banks and small flood-prone terraces along the Clearwater River.* River Alder, willows, Dogwood (*Cornus stolonifera* Michx.) and a variety of forbs are typically found in this habitat.

Habitat diversity has probably contributed to a species-rich flora within Whitemud Falls Ecological Reserve. One hundred ninety-eight vascular plant species (49 families), 57 mosses (24 families), four hepatics (three families) and 35 lichens (seven families) have been noted to date. Sixteen vascular and six nonvascular plant species are rare or disjunct in Alberta and are discussed below. Voucher specimens for all of the rare and disjunct species are at the University of Alberta herbarium (ALTA). The definition of rarity as used by Packer and Bradley (1984) in their checklist of rare plants of Alberta is employed here. Distribution of vascular plant taxa in Alberta is based on distribution maps in Packer (1983) and herbarium records at ALTA.

(2) *Rare and disjunct vascular plant species*

(a) *Cordilleran range extensions and disjunctions.* Several species of vascular plants, including *Arenaria capillaris* Poir., *Arnica lonchophylla* Greene, *Asplenium viride* Huds., *Pellaea glabella* var. *occidentalis* (E. Nelson) Butt., *Draba cana* Rydb., *Kalmia microphylla* (Hook.) Keller, have primarily boreal or northwestern montane distributions in North America. In Alberta, they occur primarily in the foothills and the montane zone of

TABLE 1. Rare and disjunct vascular and non-vascular flora of Whitemud Falls Ecological Reserve. Habitat designations (a to e) refer to habitat types discussed in the text. "Range extension" implies an extension of range without a major gap in the range of the species between previously known sites and Whitemud Falls. "Disjunction" implies a significant gap in the range between previously known sites and Whitemud Falls. Disjunctions are also range extensions, but not vice-versa.

	Significance	Habitat
Vascular plant species:		
Cordilleran extensions and disjunctions:		
Arenaria capillaris var. *capillaris*	Disjunction	(d)
Arnica lonchophylla spp. *lonchophylla*	Range extension	(a)
Asplenium viride	Disjunction	(a)
Draba cana	Range extension	(a)
Kalmia microphylla	Disjunction	(d)
Pellaea glabella var. *occidentalis*	Disjunction	(a)
Northern extensions and disjunctions:		
Arabis nuttallii	Disjunction	(c)
Carex praegracilis	Range extension	(a)
Eupatorium purpureum	Rare, range extension	(e)
Juncus confusus	Range extension, disjunction	(d)
Poa arida	Range extension	(b)
Salix amygdaloides	Range extension	(e)
Southern extensions and disjunctions:		
Gymnocarpium jessoense	Rare, range extension	(a)
Myrica gale	Uncommon, range extension	(d, e)
Polypodium virginianum	Rare, range extension	(a)
Selaginella rupestris	Rare, range extension	(b)
Non-vascular plant species:		
Amblystegium tenax	Uncommon, northern limits of range	(e)
Anomodon minor	Rare, disjunction	(a)
Myurella julacea	Rare	(a)
Neckera pennata	Rare, southern range extension	(a)
Rhodobryum ontariense	Rare, northern range extension	(a)
Timmia megapolitana	Uncommon, eastern range extension	(a)

the Rockies. The additional sites at the Whitemud Falls Reserve represent range extensions for all of these species.

Arenaria capillaris, Sandwort, is a montane species with a range extending from eastern Asia to Alaska, Yukon, British Columbia and Alberta, south to Oregon, Nevada and Montana. In Alberta the plants, which are referable to var. *capillaris*, occur in the Rockies from Jasper south to Waterton Lakes National Park. The occurrence of the species in the Whitemud Falls region represents a significant disjunction in the Alberta range of this species.

Arnica lonchophylla, Spear-leaved Arnica, occurs from Alaska to British Columbia, and east to Saskatchewan, Manitoba and Ontario. In the west, the species extends its range south down the Rockies into Wyoming. A disjunct series of populations also occur in Quebec and Newfoundland. In Alberta, populations of this species occur primarily in the Rockies with a few records from the Wood Buffalo region in northeast Alberta. The recent discovery of the site at the Whitemud Falls Reserve extends the range of the species to the northeast and adds a third locale in the province. In our region, the populations are referable to ssp. *lonchophylla*.

Asplenium viride, Green Spleenwort, has a circumboreal distribution and in North America occurs south to New York, Wisconsin, South Dakota, Colorado, Nevada, and Washington. In Alberta, the species is associated with calcareous rock cliffs and ledges in the Rocky Mountains. The site at Whitemud Falls Ecological Reserve establishes a significant disjunct.

Pellaea glabella var. *occidentalis*, Dwarf Cliff Brake, is distributed from Alberta and western North Dakota south to Colorado. In Alberta, it commonly occurs on calcareous rock cliffs and ledges in the Rocky Mountains; the site at the Whitemud Falls Reserve represents a major disjunction from the few known sites in the Alberta Rockies. It is notable that both *Asplenium viride* and *Pellaea glabella* occur only on calcareous bedrock outcrops within the Reserve.

Draba cana, Whitlow Grass, has a circumboreal distribution and in North America occurs as far south as Atlantic Canada, Ontario, northern Saskatchewan, Colorado, Utah, Nevada, Idaho, and British Columbia. In Alberta it had only been reported to occur in the Rocky Mountains from the foothills to the alpine zone. The new record from Whitemud Falls represents a significant eastward range extension in its Alberta distribution.

Kalmia microphylla, Small-leaved Mountain Laurel, occurs in montane meadows and bogs from the Yukon and the District of Mackenzie to California and Colorado. Its occurrence in the Whitemud Falls Reserve represents a disjunct population; it was previously known only from the Alberta Rockies and the Swan Hills in the west-central portion of the province.

(b) *Northern range extensions and disjunctions.*

Arabis nuttallii Robinson, *Eupatorium purpureum* L., *Poa arida* Vasey, *Carex praegracilis* Boott., *Juncus confusus* Coville, and *Salix amygdaloides* Anderss. occur primarily in the southern regions of North America and have their northern-most limits of distribution in southern Canada. The sites at Whitemud Falls represent northern range extensions for these species in Alberta.

Arabis nuttallii, Nuttall's Arabis, occurs in the mountains of southern British Columbia and Alberta south to Washington, Nevada, Utah and Wyoming, on moist grassy flats to open ridges. This species was previously known only from a few sites within Waterton Lakes National Park.

Eupatorium purpureum, Spotted Joe-Pye Weed, occurs in moist woods from Newfoundland to North Carolina, west to southern British Columbia and New Mexico. Previously, only two collections of the species had been made in Alberta, one along the Peace River in north-central Alberta and one just west of Edmonton.

Two taxa that are frequent in southern Alberta, but previously rare or unknown from northern Alberta are *Poa arida* and *Carex praegracilis*. The Plains Bluegrass, *Poa arida*, is a prairie or salt marsh plant that is native to the Great Plains; the site at Whitemud Falls is a northern extension of the range for this prairie species. *Carex praegracilis*, the Graceful Sedge, occurs in moist prairie potholes and around saline basins from Manitoba to Alaska, south to Michigan, Minnesota, Texas and California. It is common in southern Alberta, but the locality in the Whitemud Falls region is only the second site for northern Alberta.

Juncus confusus, the Few-flowered Rush, is a prairie species that is distributed from southern Saskatchewan, Alberta, and British Columbia south to Colorado and California. The species is known from six sites in Alberta: four in and around Waterton (extreme southwestern Alberta), one site in the Cypress Hills (southeastern Alberta), and one site in central Alberta near the Battle River. The site in the Whitemud Falls region is a significant disjunction.

Salix amygdaloides, the Peachleaf Willow, is associated with floodplains and pond and lake border habitats from southern Quebec and New York to southeastern British Columbia and Washington, south to Arizona, New Mexico, Texas, Kentucky, and Pennsylvania. It has been found in riparian habitats on the prairie in southeastern Alberta.

c) *Southern range extensions and disjunctions.*

Gymnocarpium jessoense (Koidz.) Koidz, *Polypodium virginianum* L., and *Selaginella rupestris* (L.) Spring, are vascular cryptogamic plants that are rare in Alberta (Packer and Bradley 1984). All three of these species are distributed across boreal Canada from the Yukon to Newfoundland and south into the eastern United States along the Appalachian and Ozark Mountain ranges. The few collections are mainly from the Peace/Athabasca River delta, in extreme northeastern Alberta, with one collection of *S. rupestris* in east-central Alberta near the Alberta-Saskatchewan border. The collections at Whitemud Falls represent slight southern range extensions.

Myrica gale L., Sweet Gale, ranges from Eurasia, Alaska and across boreal Canada to Newfoundland and south to the Great Lakes region and Appalachian Mountain Range in the eastern United States. Although not listed as rare in Alberta (Packer and Bradley 1984), it has only been reported at a few sites in the Peace/Athabasca River delta in extreme northern Alberta, and at one site further south near Fort McMurray. The collection at Whitemud Falls represents a minor southern range extension for the species.

3) *Rare and disjunct non-vascular plants.*

Six species of mosses (Bryopsida, Bryidae) that occur in the Whitemud Falls area can be considered as rare in the northeastern portion of Alberta. Like the rare vascular plants discussed above, the bryophytes have a mixture of ranges, extending into the study area from northwestern, eastern, or southeastern North America. The six species are *Amblystegium tenax* (Hedw.) C. Jens., *Anomodon minor* (Hedw.) Furnr., *Myurella julacea* (Schwaegr.) B.S.G., *Neckera pennata* Hedw., *Rhodobryum ontariense* (Kindb.) Kindb., and *Timmia megapolitana* subsp. *bavarica* (Hessl.) Brass.

Amblystegium tenax (=*Hygroamblystegium*) occurs on seasonally wet rocks along both calcareous and non-calcareous streams. It is circumboreal in distribution, and has been reported throughout Europe, North Africa, northern Asia, and Japan. In North America it has a primarily eastern range, being common from Newfoundland and Ontario south to Alabama and Arkansas (Crum and Anderson 1981). In the west it is rare, but reported from Texas,

Arizona, the Pacific Northwest, Nevada, Wyoming, Montana, and Utah. It is also known from a few collections in British Columbia. East of the Rockies, it has been collected from two localities in Saskatchewan (near Prince Albert and Amisk Lake), and from three localities in Alberta: one northeast of Fort McMurray, the second near Calgary, and the third at Cypress Hills. This is the second collection from northeastern Alberta, where it is at the northern edge of its range.

Anomodon minor was reported by Vitt and Lee (1984) from Whitemud Falls based on collections made by Peter Lee in 1983. This record represents a disjunction of about 1300 km from the nearest stations in extreme southern Manitoba. The North American range of this species was mapped by Vitt and Lee (1984) and extends from the Gaspé Peninsula west to the Winnipeg area, and south to Florida in the east, and Texas, New Mexico, and Arizona in the west. It is also disjunct in southern Mexico and Guatemala. It is a typical eastern North American deciduous forest species, occurring on the lower portions and bases of tree trunks, and on calcareous rock. The occurrence of this species at Whitemud Falls is a major disjunction, and represents an uncommon westward extension of an eastern species into the boreal forest of northern Alberta.

Myurella julacea is a montane-boreal species that is more common farther north and west. Although it is known from Alaska to Greenland, south to New England and Michigan in the east, and to Colorado and Oregon in the west, it is rare throughout central Canada due to lack of suitable habitats. The species occurs exclusively on calcareous substrates, usually in small crevices of cliff faces. It also occurs in calcareous arctic meadows, and boreal rich fens (Vitt et al. 1988). It is a typical species of montane rock outcrops throughout the Canadian Rockies.

Neckera pennata is a northern boreal species that reaches southward through the mountains in the west to Arizona, and in the east to North Carolina. It occurs across northern Canada, but becomes rare south of 60 degrees in the west. Although herbaria seem to contain quite a few collections of this species, many of them from the Canadian rockies and other montane localities are misnamed. Specimens often are *Metaneckera menziesii* (Drumm.) Steere, a western North American endemic that, in Canada, does not occur east of the eastern slopes of the Rockies. We have examined specimens of *N. pennata* from the Yukon, mainland NWT, northwestern Saskatchewan, and extreme northeastern Alberta. This report is the southernmost station in the boreal forest, east of British Columbia and west of Ontario.

Rhodobryum ontariense is a species recently segregated from *R. roseum* (Iwatsuki and Koponen 1972). *Rhodobryum roseum* has a large distribution in Europe, extending eastward into middle Asia, China, and Japan, with three localities in western North America (i.e.: near Aleza Lake, British Columbia, in the central Yukon, and on the Aleutian Islands). *Rhodobryum ontariense* is primarily an eastern North American — eastern Asian species. In North America, it is known from Newfoundland to Georgia in the east, westward to Oklahoma, South Dakota, Arizona and possibly Washington. In Alberta, it is one of our rarest mosses, known only from a station just north of Calgary, and several sites in and around Edmonton. The Whitemud Falls collection represents only the third area in the province. It has not been collected in Saskatchewan or in the Northwest Territories, and this report is the northwesternmost locality for the species in North America.

Timmia megapolitana, as a species, extends across boreal North America, Europe and Asia. It is represented by two subspecies (Brassard 1984). Subspecies *megapolitana* is a boreal-temperate taxon, known from Newfoundland, west to boreal Alberta, with a few collections reported from the Northwest and Yukon territories and Alaska. Subspecies *bavarica* is a montane-arctic taxon ranging from Greenland across the Arctic Islands to Alaska and the Yukon Territory, southward in the western mountains to Arizona and New Mexico. In boreal Canada, Brassard (1984) reported only two localities for subspecies *bavarica* east of the Rocky Mountain foothills; one on the west coast of Hudson Bay and one in east-central Saskatchewan. It was not previously known from boreal Alberta, and this report extends its known range considerably eastward at this latitude.

Conclusions

Whitemud Falls Ecological Reserve provides habitat for many rare and uncommon species, disjuncts and range extensions, especially considering its small size. Such a concentration of species is almost certainly related to the unusual suite of habitat conditions which occur within the Reserve. Of particular significance are habitats provided by: large limestone bedrock exposures (rock stacks) which are common within the Reserve but rare in Alberta east of the Rockies and foothills; small, spring-fed wetlands which are probably calcareous judging from springwater testing within the Reserve (Borneuf 1983) and which are relatively uncommon in northern Alberta; frequently flooded areas adjacent to the Clearwater River; and dry sand plains and dunes, which are local but uncommon in northern Alberta.

Limestone ledges and fissures provide substrates required by a few of the vascular cryptogams and most of the non-vascular species discussed above, and rapidly drained sands or calcareous wetlands provide suitable habitats for other vascular plants with similarly narrow requirements. Within the Reserve, however, many of the rare or disjunct vas-

cular species are not reported to occur exclusively in such restricted habitats elsewhere within their ranges. Possibly these species cannot compete within typical boreal mixedwood ecosystems (moderately moist, well drained, medium textured soils dominated by aspen) but can tolerate the less common, more extreme habitat conditions that are prevalent within the Reserve.

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Non-breeding Season Diet of Northern Saw-whet Owls, *Aegolius acadicus*, on Nantucket Island, Massachusetts

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Diet of Northern Saw-whet Owls was studied from 1985 to 1988 on Nantucket Island, Massachusetts. Eight owls were observed over a four-year period. Two hundred twenty-five prey items were recorded from 448 pellets. Two species of rodents and three species of insectivores accounted for all identified prey. White-footed Mice were dominant prey by number in three of four years, and biomass in two years. In 1987, Meadow Voles were dominant prey by number and biomass. Juveniles accounted for 56.9% of the voles eaten during the study. Based on estimated prey biomass, 74% of the prey items identified ranged between 18 and 22 grams. Food niche breadth and dietary evenness ranged from 1.31 to 2.44 and 0.430 to 0.832, respectively. Based upon skull frequencies, prey per pellet was 0.50. Mean pellet dimensions for length and width were, 29.3 x 15.5 mm.

Key Words: Northern Saw-whet Owl, *Aegolius acadicus*, diet, biomass, food niche breadth, dietary evenness, prey per pellet, pellet dimensions.

The Northern Saw-whet Owl (*Aegolius acadicus*) is endemic to North America. It is a widespread small forest owl that ranges from southeastern Alaska, south throughout the Rocky Mountains to southwestern United States, east to the Great Lakes region, southeastern Canada, and northeastern United States. Populations also occur in the southern Appalachian Mountains and a disjunct population occurs in the Sierra Madre Mountains of Mexico (Burton 1973; AOU 1983; Johnsgard 1988),

Despite this owl's wide distribution, few studies concerning its life history have been reported (Bent 1938; Palmer 1986; Cannings 1987). The most frequent information reported is diet; however, these studies are also few (Clark et al. 1978; Cannings 1987; Swengel and Swengel 1987; Marks and Doremus 1988) and separated by time and geographic location.

We provide information on the non-breeding season diet of an island population of Northern Saw-whet Owls. The owls are known to breed on the island; however, it was impossible to determine if the owls in this study were the residents or migrants. Additionally, we summarize published information on Northern Saw-whet Owl diet from other locations.

Study Area and Methods

Nantucket Island (130 km^2) is located off the southeastern Massachusetts coast, approximately 32 km south of Cape Cod and 65 km southeast of the New England coast. The island is geologically composed of moraines and out-wash plains from Pleistocene glaciation (Woodsworth and Wigglesworth 1934), and is unique in its composition of maritime heaths or "moorlands" (Tiffney and Eveleigh 1985). Human settlement and climate have kept the island free of trees until between 1870 and 1920 when pine species were introduced.

We collected Northern Saw-whet Owl pellets during the non-breeding season (December to mid-March) from 1985 to 1988. Owl roost trees were located by evidence of "whitewash" or pellets deposited below. Owls were located at each site. At least two owls were present in each year. Pellets were collected, air dried for one month, measured for length and width with a dial caliper and dissected to determine content. Skulls, mandibles and long bones were used to identify prey species. Juvenile voles were identified by comparison with total length measurement of adult skulls (Reich 1981). Skulls were often broken or fragmented; therefore, we also compared maxillary tooth row and mandibular length to identify juveniles (Pucek and Lowe 1975).

We estimated prey biomass using midpoints of weight ranges provided by Godin (1977) for New England mammals. We used midpoints because the literature is not consistent and age differences in body mass are not usually delineated.

Frequency distribution of prey was compared between years using chi-square contingency analysis (Siegel 1956). We calculated food niche breadth (FNB) using the antilog of the Shannon-Wiener diversity index: where

$$\mathrm{FNB} = \exp H^1 \quad \text{where} \; = \; - \sum_{i=1}^{s} p_i \ln p_i$$

s being the number of mammalian species and p_i the proportion of the ith mammal species in the prey

TABLE 1. Number of prey (%), and biomass (%) listed in order for each species. Body mass of prey used in biomass calculations listed below each species. Food niche breadth (FNB) and evenness for each year and combined total listed at bottom.

	1985	1986	1987	1988	1985-1988
Peromyscus	69	45	20	22	156
leucopus	(82.1)	(93.8)	(33.9)	(64.7)	(69.3)
22 g	1518	990	440	484	3432
	(72.8)	(89.1)	(22.5)	(50.2)	(56.1)
Microtus	13	—	34	11	58
pennsylvanicus	(15.5)	—	(57.6)	(32.3)	(25.7)
49 g	546	—	1428	462	2436
	(26.1)	—	(72.9)	(47.9)	(39.8)
Blarina	1	2	5	1	9
brevicauda	(1.2)	(4.1)	(8.5)	(3.0)	(4.0)
18 g	18	36	90	18	162
	(0.9)	(3.2)	(4.6)	(1.9)	(2.6)
Scalopus	—	1	—	—	1
aquaticus	—	(2.1)	—	—	(0.5)
85 g	—	85	—	—	85
	—	(7.7)	—	—	(1.4)
Sorex	1	—	—	—	1
cinereus	(1.2)	—	—	—	(0.5)
4.5 g	4.5	—	—	—	4.5
	(0.2)	—	—	—	(0.1)
Total # Prey	84	48	59	34	225
FNB	1.74	1.31	2.44	2.11	2.20
Evenness	0.580	0.430	0.832	0.811	0.580

sample (see Marti 1987). Dietary evenness was calculated using Alatalo's (1981) modification of Hill's (1973) ratio: $F = (N_2 - 1) / (N_1 - 1)$, where; N_1 is the antilog of Shannon's index (H^1) and N_2 is the reciprocal of Simpson's index (1/D) (see Marti 1987). Evenness values range from 0 to 1, therefore, as prey proportions in the owl diets become more equal, the evenness values approach unity.

We compared our FNB and evenness values with eight other studies (3 breeding season; 4 non-breeding season; and 1 combined breeding and non-breeding season). Although, Marks and Doremus (1988) calculated niche metrics for Northern Saw-whet Owl diet from the Pacific Northwest, we recalculated these. We used the Shannon-Wiener index instead of the reciprocal of Simpson's Index (Marks and Doremus 1988), because the Shannon-Wiener index places more emphasis on species richness (DeJong 1975), is linearly related to number of prey categories in the sample, and is easy to interpret (Marti 1987). We used small mammals only in the FNB and evenness calculations because they constituted over 95% of the prey eaten from each study.

Results

Five species of mammals were found in the owl pellets (Table 1). Numerically, White-footed Mice (*Peromyscus leucopus*) were the dominant prey in three of four years (Table 1). In 1987, however, Meadow Voles (*Microtus pennsylvanicus*) were the most numerous prey (Table 1). Interestingly, 33 (56.9%) of all *M. pennsylvanicus* (N = 58) were juveniles.

Biomass estimates revealed that from 1985-1988, *Peromyscus* was dominant. Coincidently, almost three times as many *Peromyscus* were eaten, compared to the second most important prey (Table 1). In 1987, biomass was also dominated by *Microtus*, while in 1988, *Peromyscus* and *Microtus* were approximately equally represented (Table 1). Prey species biomass estimates ranged from 4.5 – 85.0 g. Ninety-nine percent of the prey weighed between 18 and 42 g, while 74% of the prey weighed between 18 and 22 g. Estimates could be high for voles given that juveniles were common in the owls' diet. We feel that this would have little effect on the results.

There were significant differences in the frequency distribution of prey eaten between years ($X^2 = 59.6$, df = 6, $P < 0.001$). Food niche breadth ranged from 1.31 to 2.44 and evenness values ranged from 0.430 to 0.832 (Table 1). Food niche breadth and evenness from the grand totals (1985-1988) were 2.20 and 0.580, respectively (Table 1).

Skull remains from 448 pellets yielded approximately 0.50 prey items per pellet or 50% of the pellets did not contain skulls. Mean length and width measurements for a random sample of pellets (N = 100) was 29.3 mm (sd 5.26) and 15.5 mm (sd 1.47), range 18.5 to 42.9 and 12.2 to 21.4, respectively.

Discussion

White-footed Mice were dominant prey in this study, and *Peromyscus* spp. have frequently been reported as dominant prey in non-breeding season diet of Northern Saw-whet Owls (Errington 1932; Scott 1932; Randle and Austing 1952; Smith and Devine 1982). Additionally, *Peromyscus* spp. were dominant prey during two breeding season studies of diet (Boula 1982; Cannings 1987). *Peromyscus* spp. were also dominant in the Swengel and Swengel (1987) study; however, seasons were not separated. Catling (1972) and Grove (1985) reported the only major studies of Northern Saw-whet Owl diet in which *Peromyscus* spp. were not dominant during the non-breeding season. Marks and Doremus (1988) reported a wide range of co-dominant prey species for the breeding season. Their study, however, was a shrub-steppe desert habitat, which is atypical for Northern Saw-whet Owls (Burton 1973; Johnsgard 1988).

The occurrence of 33 juvenile Meadow Voles in the owl diets suggested that: (1) Northern Saw-whet Owls were selective for prey size; (2) dispersing juvenile voles occurred in sub-optimal habitat (i.e. pine woods) and vulnerable to predation; (3) juvenile voles are not adept as adult voles at avoiding predation, and (4) juvenile voles represented a large proportion of the vole population at that time.

In their review, Marks and Doremus (1988) reported that mean mass of mammalian prey (MMMP) for Northern Saw-whet Owls in the Pacific Northwest, ranged between 20 and 27 g and that 99% of prey weighed between 10 and 35 g. These results approximate our estimate for prey size. Hence, Northern Saw-whet Owls may be selective to prey size, but see Bent (1938) for unusual reports. In some locations, Northern Saw-whet Owl may simply occur where prey species of this size (i.e. *Peromyscus*) are the most common small mammal. This relationship needs further study.

Food niche breadth (FNB) in our study (2.20) was lower than all but one other (Table 2), indicating that Northern Saw-whet Owls on Nantucket Island preyed on a narrower assemblage of small mammals. This likely reflects that islands often have limited faunal diversity.

Evenness values from our study were near the middle range of values reported for other studies (0.395 to 0.950; N = 8; Table 1). This indicated that Nantucket owls fed primarily on one mammalian species, but that no more than two species were important in their diet.

Fifty percent of the pellets contained mammal skulls. This could imply that skulls are not good indicators of total prey eaten, or Northern Saw-whet Owls cast approximately two pellets per prey individual. Errington (1932) stated that "one fair sized mouse" probably serves two meals for Northern Saw-whet Owls. Conversely, Randle and Austing (1952) reported Northern Saw-whet Owls to eat one or two mice per evening. In a detailed laboratory study, Collins (1963) reported Northern Saw-whet Owls ate the anterior portion (head and one or two fore-legs) of laboratory mice (*Mus musculus*) weighing 25 to 30 g and the posterior portion (pelvis and hind-legs) four to five hours later, after a pellet was cast. A second pellet containing the second half of the meal was cast approximately nine hours later. In no instance did the owls swallow whole any prey that weighed 25 to 30 g. Catling (1972) observed six instances in which winter roosting Saw-whet Owls had prey (3 *Peromyscus* spp. and 3 *Microtus* spp.) clutched in their talons. In each instance, only the lower thorax, pelvis and hind legs were present. He interpreted this to indicate the owls had eaten the upper half of the body. Our pellet analysis suggested that prey was represented by two pellets.

Reports of prey per pellet (PPP) for Northern Saw-whet Owls do vary, and calculations made by us from other studies revealed values of 0.64,0.64,

TABLE 2. Numbers, food niche breadth (FNB) and evenness values of breeding and non-breeding season Saw-whet Owl diet from nine studies. Only mammals were used in the calculations.

# PREY	FNB	EVENNESS	LOCATION	SOURCE
BREEDING SEASON				
714	3.91	0.950	Idaho	Marks and Doremus 1988
584	3.05	0.680	British Columbia	Cannings 1987
77	2.40	0.395	Oregon	Boula 1982
NON-BREEDING SEASON				
770	2.97	0.742	Washington	Grove 1985
276	3.41	0.734	Connecticut	Smith and Devine 1982
225	2.20	0.58	Massachusetts	This study
173	2.11	0.713	Ontario	Catling 1972
113	4.60	0.653	Ohio	Randle and Austing 1952
BREEDING AND NON-BREEDING SEASON				
242	2.50	0.465	Wisconsin	Swengel and Swengel 1987

0.65, 0.81, 1.03 PPP for samples with greater than 100 pellets per study (Randle and Austing 1952; Catling 1972; Smith and Devine 1982; Grove 1985; Swengel and Swengel 1987), respectively. Our mean length and width pellet dimensions were similar to those reported by Catling (1972) (33.5 x 15.7 mm; N = 270) and Smith and Devine (1982) (30.2 x 15.5 mm; N = 269).

Rusling (1951) stated that "no other owl appears to show such a decided preference for white-footed mice." The present study and literature herein indicate that Northern Saw-whet Owls eat predominately *Peromyscus* spp.; however, there appears to be some diversity or flexibility in the owls' diet. Additional food habits studies and prey availability data are needed from other locations for a thorough understanding of Northern Saw-whet Owl diet and feeding ecology.

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Notes

Orconectes limosus (Crustacea: Cambaridae), an addition to the crayfish fauna of New Brunswick

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McAlpine, Donald F., William E. Hogans, and Timothy J. Fletcher. 1991. *Orconectes limosus* (Crustacea: Cambaridae), an addition to the crayfish fauna of New Brunswick. Canadian Field Naturalist 105(3): 386–387.

The crayfish, *Orconectes limosus*, is reported from New Brunswick for the first time from collections from two tributories of the St. Croix River. This is only the second substantiated occurrence of this crayfish in Canada.

Key Words: *Orconectes limosus*, crayfish, New Brunswick, distribution.

In the Maritime Provinces of Canada, crayfish have been reported only in the drainages of the St. John, Miramichi, and Restigouche Rivers of New Brunswick. Until now, *Cambarus bartoni* has been the only crayfish identified from the province. Here we report the first records of the crayfish *Orconectes limosus* from New Brunswick. These records also represent only the second substantiated occurrence of this crayfish in Canada, a species with a distribution in the United States that extends from Maine south to the lower James River in Virginia (Hobbs 1989).

Ganong (1887, 1898) summarized known occurrences of *C. bartoni* in New Brunswick up to that time but most of the information presented was anecdotal and he included a plea for further specimens and observations. In 1976 and 1984 Schueler (1985) searched stream habitats specifically for crayfish at 16 sites over the northwestern, central and southern portions of the province. At seven sites in the northwest he collected the crayfish *C. bartoni* but found none in the south. Walker (1985) reported four observations of crayfish from the Miramichi and its tributaries, but did not identify the species.

On 25 September 1987 WEH collected five specimens of *Orconectes limosus* from Canoose Stream, a tributary of the St. Croix, at a site 45 km NW of St. Andrews, Charlotte County, New Brunswick (45°23'N; 67°21'W). The crayfish were collected by electrofishing in a section of stream characterized by riffles, current of moderate velocity, and a bottom composed of gravel, sand and small stones. Depth of the stream at the sample site was 35 cm; water temperature at the time of collection was 13°C. The single male and four females range in carapace length from 28.6 to 40.8 mm. On 12 June 1990, DFM and TJF collected three males and two females of *O. limosus* from similar habitat in Mohannes Stream (45°22'N; 67°21'W). This is also a tributary of the St. Croix, 20 km south of the Canoose Stream site. The carpace lengths of these specimens range from 13.0 to 22.6 mm. Individuals have been deposited in the invertebrate collections of the New Brunswick Museum (NBM 8236, NBM 8237).

The records reported here are not surprising. Crocker (1958) who first noted the presence of *O. limosus* in Maine, reported it from three adjacent drainages scattered across the south of the state. The surveys of P. S. Andrews (1973. Maine Forage Crustacean Study, Project F-23-R, Job A-1, Unpublished Final Report, State of Maine) verified that this crayfish is widely distributed across the southern half of Maine. In October 1975, specimens of *O. limosus* were collected in the St. Croix River at Vanceborough, Maine (NBM 271, NBM 269) at a site only 2km west and 20 km north of our Canoose Stream record.

Faxon (1885) and Hagen (1870) first reported *Orconectes limosus* in Canada from Lake Superior and Lake Superior and Niagara, Ontario, respectively, but Ortmann (1905) felt these records were unacceptable. *O. limosus* was later recorded from Iroquois, Dundas County, Ontario, by Huntsman (1915) but the specimens are no longer extant and Crocker (1957) considered the report unreliable. Crocker and Barr (1968) were unable to recollect the species in the province although they suggested that *O. limosus* might be found in Ontario. In 1982, Couture and Savignac (1984) reliably documented *O. limosus* in Canada. They reported that *O. limosus* constituted 84% of 1149 crayfish captures in the St. Lawrence River in an area from Sorel to Quebec city, Quebec.

Reid (1970) suggested that *O. limosus* may be still expanding its range in Maine, and noted that the species is secretive and difficult to trap. It is not possible to determine whether the crayfish records reported here represent a recent range expansion into New Brunswick or are simply the result of previous inadequate sampling.

Acknowledgments

We are grateful to Dr. William F. Reid Jr., State of Maine Department of Transportation, and Mr. John Enright, Maine Natural Heritage Program, for supplying information on the range of crayfishes in Maine. An anonymous reviewer drew our attention to Quebec records for *O. limosus*.

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Flowering Rush, *Butomus umbellatus*, a New Record for Alberta

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Scotter, George W. 1991. Flowering Rush, *Butomus umbellatus*, a new record for Alberta. Canadian Field-Naturalist 105(3): 387–389.

A colony of *Butomus umbellatus* (Flowering Rush) is reported from the Sturgeon River in Alberta. This is the first known occurrence in the wild in Alberta.

Key Words: *Butomus umbellatus*, Flowering Rush, Alberta, new record.

On 30 June 1990, I collected *Butomus umbellatus* (Flowering Rush) along the banks of the Sturgeon River within the town of St. Albert, Alberta. Specimens (Scotter 89600 and 89600A) were deposited in the herbarium of the Biosystematics Research Centre, Agriculture Canada, Ottawa (DAO) and the herbarium of the Department of Botany, University of Alberta, Edmonton (ALTA). This collection appears to be the first to be made in Alberta. The plants were rooted in mud and growing in 10 to 30 cm of water. There were twenty flowering stems within four clumps. These many-flowered plants were nearly a metre tall. The large and showy rose-coloured petals, enclosed by threepurplish involucral-like bracts, were just starting to open (Figure 1).

Plants associated with *B. umbellatus* included: *Potamogeton richardsonii* (Richardson's Pondweed), *Sagittaria cuneata* (Arum-leaved Arrowhead), *Agropyron trachycaulum* (Slender Wheatgrass), *Beckmannia syzigachne* (Slough Grass), *Glyceria grandis* (Tall Manna Grass), *Phalaris arundinacea*

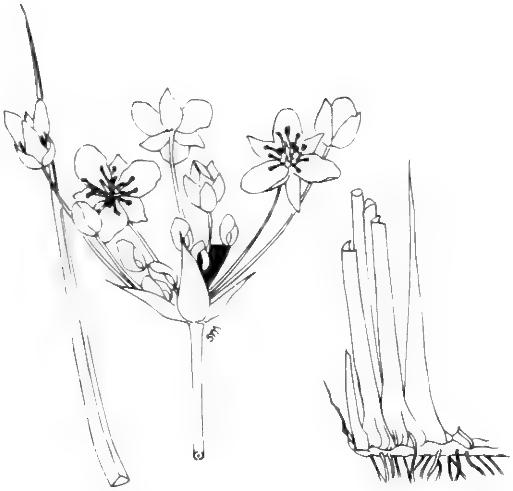

FIGURE 1. Line drawings of a *Butomus umbellatus* as found along the Sturgeon River, Alberta.

(Reed Canary Grass), *Scirpus validus* (Great Bulrush), *Eleocharis palustris* (Creeping Spike-rush), *Lemna minor* (Duckweed), *Spirodela polyrhiza* (Large Duckweed), *Myriophyllum exalbescens* (Water Milfoil), *Polygonum lapathifolium* (Pale Persicaria), and *Sium suave* (Water-Parsnip).

The first North American observation of *B. umbellatus* was made in 1897 at La Prairie, Quebec (Marie-Victorin 1908). The rapid spread of this non-indigenous aquatic in the Great Lakes and the St. Lawrence River has been well documented by Core (1941), Gaiser (1949), Stuckey (1968), and Scoggan (1978). *B. umbellatus* was also reported from Nova Scotia (Hall 1959), Prince Edward Island (Erskine 1960), South Dakota (Martin 1965), Idaho (Hitchcock et al. 1969), the Mississippi watershed (Roberts 1972), Montana (Hahn 1973), North Dakota (Godfread and Barker 1975), Minnesota (Godfread and Barker 1975), and British Columbia (Brayshaw 1985). It was first reported in the Canadian prairies from Manitoba in 1977 (Staniforth and Frego 1980). The Sturgeon River colony is approximately 1200 km NW of the reported Manitoba sites at Netley Marsh, Patricia Beach and Lockport, 800 km NE of the Hatzic Lake site in British Columbia, and 650 km N of the nearest United States site in Flathead County, Montana.

Staniforth and Frego (1980) predicted that *B. umbellatus* "... will become an abundant and widespread species in freshwater marshes of the Canadian prairies in the near future." The Sturgeon River stand bears out their prediction, and the plant should be watched for in similar areas.

Dispersal of the species can be accomplished by seeds which float and remain viable for long periods of time and from many freely deciduous tubers from stout fleshy rhizomes that may be moved by water currents or ice movements. Because of its ecological plasticity and great reproductive potential, the impact of *B. umbellatus* on natural vegetation and waterfowl habitat should be carefully monitored.

Anderson et al. (1974) suggested there are two forms of *B. umbellatus*; tall-stemmed, many-flowered plants from Europe and smaller plants from Asia (sometimes referred to as *B. junceus*). The Sturgeon River material would appear to be the European type.

The origin of the small colony along the Sturgeon River is unknown. The site is upstream from Hole's Greenhouses and Gardens Ltd. which sells some aquatic plants. Hole's stocked *B. umbellatus* during 1985 only (Bob Stadnyk, personal communication). The plants may represent introductions or escapes from cultivation. The possible role of waterfowl in the dissemination of *B. umbellatus* should be considered since the Sturgeon River is an important habitat for waterfowl from the Pacific, Central, and Mississippi flyways in the spring and fall.

Mrs. Joan Rudyk of St. Albert, who showed me the *B. umbellatus* colony on the Sturgeon River, believes the plant has been present for at least five years. She observed a single flowering stem in about 1986.

Acknowledgments

Thanks are extended to J. Rudyk for showing me the collection site and to W. J. Cody, Biosystematics Research Centre, for verification of my identification. Thanks also to S. MacEachran for providing the line drawings.

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Arctic Tern, *Sterna paradisaea*, Kills Piping Plover, *Charadrius melodus*

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Flemming, Stephen P. 1991. Arctic Tern, *Sterna paradisaea*, kills Piping Plover, *Charadrius melodus*. Canadian Field-Naturalist 105 (3): 389–390.

Evidence indicated that an Arctic Tern, *Sterna paradisaea*, killed an adult female Piping Plover, *Charadrius melodus*. Aggressive encounters between the two species occurred during the Arctic Tern's pre-laying stage. Piping Plovers charged Arctic Terns that landed near their nests. Plovers were opposed by the Tern's bill or were pecked. These observations contrast with previously reported benefits gained by Piping Plovers that nested with Least Terns *S. antillarum*.

Key Words: Piping Plover, *Charadrius melodus*, Arctic Tern, *Sterna paradisaea*, interspecific encounters.

Piping Plovers, *Charadrius melodus*, occasionally nest in tern colonies (Flemming unpublished; Burger 1987.) Burger (1987) suggested that reproductive success of Piping Plovers might be enhanced by nesting in a Least Tern, *Sterna antillarum*, colony. Reported here are interspecific encounters between Arctic Terns, *S. paradisaea*, and Piping Plovers that may raise questions on the benefits of nesting in the colonies of some species of terns.

Observations were made in Nova Scotia while I was conducting research on the behaviour and status of the Piping Plover (Flemming et al. 1988). On 28 May 1987 at 18:30 AST, I checked a plover nest on Johnstons Pond Beach (43°45'N, 64°57'W), located in an Arctic Tern colony (approximately 20 pairs). I found a dead adult female Piping Plover 120 cm from its nest, with two wounds on its head. The bird must have been dead for 30 min to 2 h before my arrival because *rigor mortis* had not yet begun, and the body was still warm, but blood on the head wounds had dried. Inspection of the vicinity (25 m diameter) showed no tracks other than plovers, except those of terns. Within 7 m of the nest were at least five fresh tern scrapes, including one within a meter of the dead plover. The eggs were not fostered (c.f. Flemming 1987) because the male was still defending the territory, and I thought that he might be able to rear them on his own. On 4 June 1987 the eggs were evidently abandoned, and subsequent visits indicated that the male had acquired a new mate and a new nest.

A post-morten examination confirmed that the plover was a female, and established that the cause of death was two punctures, by a sharp object, which pierced the cranium and entered the brain. The tip of an Arctic Tern's bill (from specimens in the Wildlife Museum of Acadia University) corresponded precisely to the shape of the wounds on the plover. The skin of the female plover was subsequently donated to the museum (Catalogue number 2351).

In 1983, during the Arctic Tern's pre-laying stage, I noted five aggressive encounters between plovers and terns at Johnstons Pond Beach (N = 44 hours observation). Typically, the encounters involved a tern landing within 3 m of a plover nest, where upon the plover responded by charging the intruding bird. In four instances, the tern was attempting to make a scrape for a potential nest site. These Piping Plovers were largely ineffective in supplanting the terns, as the latter's response was to stand its ground, opposing the plover with its bill. However, in one instance, the response was more aggressive, as a tern fiercely pecked a plover's back.

I contend that an Arctic Tern killed the female Piping Plover. The only sign of other animals was of Arctic Terns which had been digging scrapes near the plover's nest. This, with my 1983 observations from the same beach, and the match between the plover's wounds and an Arctic Tern's bill, provide compelling evidence that an Arctic Tern killed the plover. This seems to be the first recorded evidence of a Piping Plover being attacked and killed by any species of tern.

Burger (1987) found that when Piping Plovers were forced to renest, they preferentially did so within a Least Tern colony if one was nearby. However, Least Terns being much smaller than Arctic Terns may not pose as great a threat to plovers. Hence, the benefits of nesting with Least Terns may outweigh the costs. Given my observation, it seems plausible that the opposite might be true for nesting in an Arctic Tern colony. Nesting with some species of terns may not be beneficial to Piping Plovers. Efforts to manage tern colonies in order to benefit plover conservation (Goossen 1990) should proceed with caution until more information is available on the costs and benefits of the plover-tern relationship.

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New Location Reports of Nearctic Branchiobdellidans (Annelida: Clitellata)

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Gelder, S. R. 1991. New location reports of Nearctic branchiobdellidans (Annelida: Clitellata). Canadian Field-Naturalist 105(3): 390–391.

Cambarincola mesochoreus is reported for the first time from Ontario on *Orconectes virilus*. *Cambarincola barbarae* and *C. pamelae*, reported previously only from California, were found with *C. mesochoreus* on *Procambarus (Scapulicambarus) clarkii* from Louisiana.

Key Words: Ontario, Louisiana, branchiobdellidans, new records.

Branchiobdellidans are leech-like, ectosymbiotic clitellates that usually live on the surface of freshwater crayfish (Holt 1986; Brinkhurst and Gelder *in press*). Identification of branchiobdellidan species is considered difficult because the taxonomic keys and diagnoses are based on internal, anatomical features. Knowledge of a species distribution by province or state can provide a useful adjunct to a miroscopical examination in species identification. Here, I report new records for Ontario and Louisiana.

Ontario, Canada

During a study by the Ontario Ministry of the Environment into the effects of acid rain on crayfish cuticle calcification, crayfish were collected in September 1989 from Big East, Crosson, Clear, and Gullfeather lakes, in the vicinity of Route 118 crossing Haliburton County/Muskoka District line, Ontario (45°02'N, 79°00'W). Three additional *Orconectes virilis* (Hagen, 1870) from each lake were taken, preserved, and sent to my laboratory by Kathryn A. Coates for the identification of any attached branchiobdellidans. Specimens of *Cambarincola mesochoreus* Hoffman, 1963, were found: one from each of Big East and Crosson Lakes, and 14 from Clear Lake, but none from Gullfeather Lake. These provide the first records of this species in the Province.

Louisiana, USA

Specimens of the crayfish *Procambarus* (*Scapulicambarus*) *clarkii* (Girard, 1852), collected from Terrebone and LaFourche Parishes (29°30'N, 90°20'W and 29°20'N, 90°45'W respectively), were supplied to me during August 1989 and again in March 1990 by Waubum Laboratories, Shriever, Louisiana. Living on the dorsal carapace, particularly the anterior region, were adult specimens of *C. mesochoreus*, approximately 3.O mm long. This species was already known from the area as Hoffman (1963: 307, 309) had corrected the report of *C. macrodonta* (in part) by Ellis (1919) from Morgan City, Louisiana, to *C. mesochoreus*.

A close inspection of the living crayfish revealed numerous smaller branchiobdellidans, about 2.0 mm long, in the oral region and along the ventral surface of the host. These shorter specimens consisted of both *Cambarincola barbarae* Holt, 1981, and *C. pamelae* Holt, 1984. Previously (Holt 1981) had identified *C. mesochoreus*, *C. fallax* Hoffman, 1963, and *C. barbarae* on *P. (S.) clarkii* collected from California. Holt (1981:679) suggested that these three species were probably introduced into California on their host, *P. (S.) clarkii*. The specimens identified as *C. mesochoreus* in Holt (1981) were transferred into the new species *C. pamelae* by Holt (1984), thus removing *C. mesochoreus* from Californian distribution. Holt (1984: 548) further discussed the question of species introduction into California but felt that *C. pamelae* ". . . probably is not, an eastern, introduced species." The presence of *C. barbarae* and *C. pamelae* on *P. (S.) clarkii*, endemic to Louisiana, supports the earlier hypothesis (Holt 1981) that all of these species were introduced into California.

Because there have been few reports of branchiobdellidans in Canada (Robinson 1954; Bishop 1968; Gelder and Hall 1990), the northern limit of their Nearctic distribution remains to be established. It is hoped that future studies on the Branchiobdellida will be stimulated in Canada by drawing attention to the lack of this fundamental knowledge.

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Pollination and Breeding Biology of Large-flowered Bellwort, *Uvularia grandiflora*

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The pollination and breeding biology of *Uvularia grandiflora*, a spring flowering herb, was studied in central Illinois. Outcrossing was the primary mode of sexual reproduction. The principle pollinators were queen bumblebees (*Bombus griseocollis*). A suite of adaptations, including flower morphology, phenology, amount of pollen, and pattern of anther dehiscence, were consistent with queen bumblebee pollination.

Key Words: Large-flowered Bellwort, *Uvularia grandiflora*, *Bombus griseocollis*, pollination, breeding biology.

Large-flowered Bellwort, *Uvularia grandiflora* SM., is a spring-flowering perennial herb found in deciduous forests from southern Quebec south into Georgia and west into Arkansas, the eastern Dakotas and southern Ontario (Wilbur 1963). Little is known about the species' ecology or reproductive biology. The only previous study dealing with the reproductive biology of the genus was by Whigham (1974) on Perfoliate Bellwort, *U. perfoliata* L. The purpose of this study was to evaluate the breeding biology and identify pollinators of *U. grandiflora*.

Study Area and Methods

Our study site was located in Trelease Woods, approximately 10 km northeast of Urbana, Illinois (40°15'N, 88°08'W). This 24-ha woodland is dominated by a mixed canopy of Sugar Maple (*Acer saccharum* Marsh.), Hackberry (*Celtis occidentalis* L.), White Ash (*Fraxinus americana* L.), Red Elm (*Ulmus rubra* Muhl.), Basswood (*Tilia americana* L.), and Red Oak (*Quercus rubra* L.) (Kendeigh 1982). Infrequent, disjunct patches of *U. grandiflora* were present in the study area.

Four treatment groups and an open-pollinated control group of plants were established in the spring of 1981 to determine the breeding system of *U. grandiflora*. Treatment groups were as follows: 1) Apomixis; 2) Forced self-pollination; 3) Forced cross-pollination; and 4) Not manipulated and bagged. Plants in the first three treatments were emasculated prior to anthesis. Bags made of nylon organdy were then pinned in place over individual flowers to prevent pollinator access. Pollen transfers for forced self and cross-pollination were performed when the three-parted stigma was reflexed. Forced self-pollination was conducted by pollen transfers between flowers on adjacent flowering stalks with a common rhizome, or between flowers of the same stalk. Pollen for forced-outcrossing was obtained from separate patches of *U. grandiflora* because of its extensive rhizome. We wanted to avoid the possibility that pollen within a local patch could be largely of one genotype. After pollen was transferred, bags were replaced. To evaluate self-pollination in the absence of a pollinator (treatment 4), plants were "bagged" prior to anthesis. Bags remained on all treatments until the seeds were harvested. Open-pollinated controls were randomly chosen and untreated. All seed capsules were harvested when the seed pods matured. The number of ovules and seeds per capsule and seed weights were recorded. Differences among treatments were evaluated using ANOVA and the t-test (Sokal and Rohlf 1981).

Notes on flowering phenology, floral morphology, pollinators and their movements, and herbivores were made.

Results

U. grandiflora flowered the first week of April and continued until the first week in May. The rhizomes of *U. grandiflora* were commonly connected to both flowering and non-flowering stalks. Two to three light yellow flowers developed sequentially on most flowering stalks, but occasionally two flowers could be found open together on the same stem.

Flowers ranged from 2.5 to 5 cm in length and hung in a pendant fashion from the axil of a leaf (Figure 1). A flower remained enclosed in furled leaves until anthesis. The six anthers dehisced in two groups of three, with every other anther belonging to one group. As the flower opened, the stigma reflexed, and the first group of three anthers began dehiscing simultaneously. A slit opened at the base of the long (18 mm) anther and progressed to its apex as dehiscence continued. Each anther produced pollen for approximately 2–3 days. As the first set of

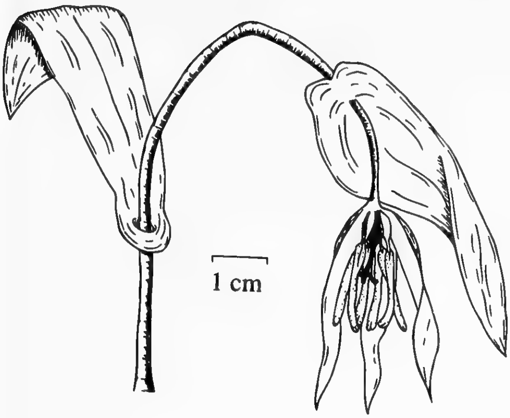

FIGURE 1. Flowering stem of a Large-flowered Bellwort, *Uvularia grandiflora*. The flower has some perianth parts removed.

three anthers finished dehiscing, the second set began. Thus pollen presentation lasted for a total 4–6 days during the life of a flower. The corolla began to wither approximately one week after opening. Ovules ranged from 6 to 14 per locule (x = 11.4, s.d. = 2.95). The capsule matured and seeds dehisced from mid-July to early August.

U. grandiflora is mostly self-incompatible, with few seeds resulting from apomictic, self, or bagged treatments (Table 1). The open pollinated control and forced cross-pollinated groups produced significantly more seeds than the other treatments. Control seeds were significantly heavier than forced cross-pollinated seeds ($p < 0.001$, t-test), and though not significant at the 0.05 level, cross-pollinated flowers tended to produce more seeds than control flowers ($0.1 < p < 0.05$, t-test). Number and size of seeds in a capsule showed a negative but insignificant correlation ($r = 0.24$, $0.05 < p < 0.1$). Multiplying average seed number by average seed weight for forced cross-pollinated and open-pollinated capsules (a rough estimate of resources used per capsule), resulted in both groups having identical average capsule weights of 0.18 g/capsule.

With the exception of one *Andrena* sp. that was found inactive inside of a flower, only the bumblebee, *Bombus griseocollis* De Geer, was seen visiting *U. grandiflora* flowers. All *B. griseocollis* observed (23) were queens except two workers collecting pollen in late April and early May. The first queens observed visiting the *U. grandiflora* flowers were not collecting pollen as indicated by empty corbicula; however, pollen was observed on their mandibles. Foraging movements were usually directional through a patch with the bee flying from one flower to the next neighboring flower.

Only one flower hervivore, a curculionid beetle, was seen during the study. This beetle was first observed in early April feeding on pollen from undehisced anthers. None of the anthers with feeding damage released pollen.

Discussion

Whigham (1974) found *U. perfoliata*, like *U. grandiflora*, also was largely self-incompatible. *B. griseocollis* was the only pollinator we observed on *U. grandiflora*, and 91 percent of these were queens. Whigham (1974) reported an unidentified "flightless" staphylinid beetle to be the pollinator of *U. perfoliata*. We find this observation questionable as the two *Uvularia* species are morphologically and phenologically very similar. It seems a contradiction that a flightless beetle would be the principle pollinator of a plant species that needs outcrossing and also reproduces extensively by rhizomes (i.e. most neighboring flowers would be of the same genotype).

Uvularia grandiflora is particularly suited for queen bumblebee pollination. The yellow coloration is a typical color preferred by bees. The pendant, bell-shaped flower requires the pollinator to hover, grasp, and crawl up into the flower to obtain nectar and/or pollen. A large-bodied pollinator would more likely contact the anthers and reflexed style than a small-bodied pollinator.

TABLE 1. The means ($\bar{x}$) and standard errors of the means (SEM) for seed number and seed weight of *U. grandiflora* pollination treatments and control. The F-value was calculated from ANOVA, and least significant difference (LSD) was used to compare differences between treatment means at $p = 0.05$. Significant differences between treatments are denoted by different letters (in parentheses).

	Seed Number/Capsule				Seed Weight (gm)			
Treatment	Capsule number	$\bar{X}$	SEM	F	Seed number	$\bar{X}$	SEM	F
Apomixis	17	0.29(A)	0.19		5	0.023(A)	0.003	
Bagged (not manipulated)	20	0.80(A)	0.28		16	0.029(B)	0.002	
Forced self-pollination	11	1.09(A)	0.49		12	0.027(C)	0.002	
Forced cross-pollination	24	9.25(B)	1.11		222	0.019(D)	0.000	
Control (open-pollination)	22	6.82(B)	0.74		150	0.026(C)	0.001	
				30.25***				28.94***

***$p < 0.001$

Uvularia grandiflora flowered in late March to early April, coinciding with the emergence of spring queens. Though not in the earliest wave of Illinois spring flowers, including *Claytonia virginica*, *Dentaria laciniata*, *Dicentra canadensis*, *D. cucullaria*, *Erythronium albidum*, *Isopyrum biternatum* and *Sanguinaria canadensis* (Schemske et al. 1978), *U. grandiflora*'s flowering season overlapped with these early species, appearing before the canopy closed. Workers of *B. griseocollis* did not appear until the end of the flowering period. Copious amounts of pollen were produced throughout the life of the flower. With two sets of three anthers dehiscing sequentially, fresh pollen was continuously available. This is particularly beneficial for queen bumblebees, which early on require pollen for maturing their ovaries (Alford 1975) and subsequently need it for rearing their brood.

Since the plant produces rhizomes, each patch of *U. grandiflora* could potentially be a large clone. If this were true and because pollinator foraging movements were from neighbor to neighbor, a large percent of flowers within a patch could receive pollen from the same genet and result in a lower seed set. Since 100 percent of naturally-outcrossed flowers set seed, either patches were composed of two or more genetically distinct individuals, or pollen carryover from outside patches was significant.

There was a trend for hand-outcrossed flowers to produce more seeds per capsule than open-pollinated flowers. Willson and Burley (1983) argue pollen limitation is a cause of reduced seed set. Ockendon and Currah (1977) showed self-pollen may interfere with outcrossed pollen and prevent pollination or at least reduce it. Self-pollen mixed in the deposited pollen loads of naturally-pollinated flowers may have reduced seed set when compared to the forced outcrossed group.

Because capsule weight was similar between open- and cross-pollinated treatments, it appears there may be a resource limit on the number of seeds per capsule. Fewer fertilized seeds could have the effect of making more resources available for remaining seed development, explaining the significantly larger seed size of the open-pollinated controls. We would expect a negative correlation to exist between number and size of seeds in a capsule. Our data showed a negative but insignificant correlation. Alternatively, the significantly larger seed size of open-pollinated vs. hand-outcrossed groups may be due to outbreeding depression. Price and Waser (1979) found that pollination of *Delphinium nelsoni*, at increasing distances from the donor individual, resulted first in inbreeding depression followed by an apparent optimum genetic distance from the pollen donor and finally outbreeding depression.

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Effect of a Nesting Predator on Concealment Behaviour of Potential Prey Species

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I examined whether three potential prey species, the House Sparrow (*Passer domesticus*), Chipping Sparrow (*Spizella passerina*) and American Robin (*Turdus migratorius*) conceal and expose themselves differentially in relation to their proximity to Merlin (*Falco columbarius*) nests. The House Sparrow is the principal prey of Merlins during the survey month (May), while the American Robin is occasionally and the Chipping Sparrow rarely taken as prey. I recorded whether these birds were concealed or exposed at 100 m intervals from 0–400 m away from Merlin nests. Significantly more House and Chipping sparrows were in concealed situations near Merlin nests. The proximity to Merlin nests did not affect the concealment of American Robins.

Key Words: Merlin, *Falco columbarius*, House Sparrow, *Passer domesticus*, Chipping Sparrow, *Spizella passerina*, American Robin, *Turdus migratorius*, concealment behaviour.

Individuals nesting close to a predator's nest often experience higher reproductive success than individuals nesting further away (Collias and Collias 1984). This is apparently due to nest defence by the associated predator species which deters other potential predators (Clark and Robertson 1979; Wiklund 1982). Other studies have shown that there is often a depression in the abundance of potential prey species near a predator's nest (Eng and Gullion 1962; Geer 1978; Meese and Fuller 1989; Sodhi et al. 1990). This depression caused by either predation (Eng and Gullion 1962; Geer 1978) or avoidance of such areas by the potential prey species (Meese and Fuller 1989; Sodhi et al. 1990). Nesting predators cause some prey to fly close to ground near their nests (Meese and Fuller 1989) or influence flocking behaviour of other prey species (Sodhi 1991). No study has been done to examine if potential prey species differ in cover utilization with respect to distance from a predator's nest.

In this paper, I present data relevant to the following questions: (1) Do potential prey species conceal themselves when close to a Merlin's (*Falco columbarius*) nest? and (2) If so, is this behaviour associated with the likelihood of predation on different species? I predicted that I would encounter more birds in cover near a Merlin's nest, e.g. as shown for foraging birds (Lima 1985). This strategy may be important in predator avoidance if the predator's nesting location is known due to breeding displays and calls of the predator, but the bird's exact location may not be known at all times owing to its inconspicuousness.

Methods

I recorded the locations of three potential prey species, the House Sparrow (*Passer domesticus*), American Robin (*Turdus migratorius*), and Chipping Sparrow (*Spizella passerina*), near five Merlin nests, on randomly selected transects (from available transects radiating from the nests by tossing a coin; one transect/nest) in Saskatoon (52°07'N, 106°38'W), Saskatchewan. Warkentin and James (1988) and Oliphant and Haug (1985) described the study area and local Merlin nesting history. The House Sparrow was the most frequently consumed species (about 58% numerically of the Merlin diet, based on analysis of 159 prey items collected near 16 nests in May 1988; Sodhi, unpublished data), whereas American Robin was eaten occasionally (6%), and the Chipping Sparrow only rarely (1%).

Bird counts were made every 100 m beginning at the nest and ending 400 m from the nest. At each count point, I recorded birds seen within a 30 m radius for 5 min and placed them in the following categories: flying; at the periphery of cover (trees, shrubs, etc.); in cover; perched on a pole, roof and fence tops; and outside cover. The behaviour of each individual was recorded when it was first seen; e.g., if a bird was detected first in cover and then it flew out, it was recorded in cover only (because flight may be in response to the observer). A preliminary survey with 10 min counts revealed that bird numbers reached an asymptote in 3 min (n = 5 point counts). However, in this study 5 min counts were made at each point so that a careful search of the area could be made to remove, or minimize, the bias caused by interspecific differences in conspicuousness.

I assumed that birds which were flying, those at the periphery of cover; on poles, roofs and fence tops; or outside cover were exposed and vulnerable to Merlin predation. The birds in cover were assumed to be more concealed and hence less vulnerable. Each transect was surveyed twice during the first 4 h of daylight and in fair weather (<10% cloud

TABLE 1. Number of birds in exposed and concealed locations at different distances from five Merlin nests.

Distance (m)	House Sparrow		Chipping Sparrow		American Robin	
	Exp	Con	Exp	Con	Exp	Con
0	19	34	2	11	8	2
100	43	13	10	5	10	0
200	54	4	18	2	12	1
300	62	8	15	3	7	0
400	55	9	9	5	11	0

cover and <15 km/h wind speed) betwen 26 and 30 May 1989. Female Merlins are incubating at this time and males do all the hunting. On average, males spend about 70% of their time within 100 m of the nests (based on a total of 120 h of radio-tracking involving five males in May, two in 1988 and three in 1989; Sodhi, unpublished data). The males primarily hunt away from their nests, but make opportunistic hunting attempts near their nests (see Sodhi 1991).

To assess cover availability at different distances from the Merlin nests, I recorded the number of trees and shrubs within 30 m of each count point. The chi-square tests revealed no significant difference in the number of trees and shrubs recorded at different distances from any of the nests (df = 4, $p > 0.05$).

Results and Discussion

I found that near the Merlin nests, there were significantly more House Sparrows in concealed situations ($\chi^2 = 60.92$, df = 4, $p < 0.001$; Sokal and Rohlf 1981: 744–746; Table 1). Similar was the case with the Chipping Sparrows ($\chi^2 = 23.20$, df = 4, $p < 0.001$), but not with the American Robins ($\chi^2 = 5.46$, df = 4, $p > 0.05$).

The results suggest that House and Chipping sparrows conceal themselves more when close to Merlin nests. In addition to avoiding the areas occupied by nesting Merlins (see Sodhi et al. 1990), this may be a predator avoidance tactic used by both these species. House Sparrows are eaten by foraging Merlins more than Chipping Sparrows, possibly because they were more abundant and exposed in greater numbers than the Chipping Sparrows (Table 1).

My data also suggest that nesting Merlins do not have an affect on the concealment behaviour of the American Robins. Robins have aggressive nest defence (Gottfried et al. 1985) and they frequently attack Merlins which venture close to their nests (personal observation). Their aggressiveness may provide them with some protection if they are nesting close to Merlin nests (Errington 1967). The question of why more American Robins are in exposed situations near Merlin nests in spite of their suitability as prey is interesting and deserves further study.

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A Longevity Record for Dall Sheep, *Ovis dalli dalli*, Yukon Territory

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Of 143 Dall Sheep marked in Kluane National Park during the winters of 1970-1971 and 1971-1972, all have now died; the last two disappeared in the winter of 1988-1989. One recovered carcass was a ewe marked in 1970-71, born May 1969. She died at age 19 years 10 months. The other ewe would also have been 19 to 20 years old. These exceed the oldest record in the literature by over three years, but previous maximum ages are based on skull inspections. Methods of aging by the horn annulus technique may underestimate true age. Use of this technique gave an age of only 18 years for the ewe reported on here. Although this ewe showed aberrations of the tooth arcade and mandible, presumably caused by bacterial infection, this condition does not appear to lower productivity or longevity.

Key Words: Dall Sheep, *Ovis dalli dalli*, Kluane National Park, Yukon Territory, aging techniques, longevity.

The Sheep Mountain population of Dall Sheep (*Ovis dalli dalli*) in Kluane National Park, Yukon, has been under surveillance for more than 20 years. Intensive research on this herd began in 1969 (Hoefs and Cowan 1979) and was continued after park reserve establishment in 1972 in cooperation with Kluane National Park staff (Hoefs and Bayer 1983; Hoefs 1984). During the winter of 1970-71 and 1971-1972, 143 sheep were live-captured for marking purposes (Olson 1972, Sheep capture and marking on Sheep Mountain, unpublished report on file with Parks Canada). The presence of the marked sheep with known birth-dates allowed an accurate determination of age at death, since the horn ring or tooth sectioning techniques for age determination are not very reliable for old ewes (Hoefs and König 1984).

Over the years, all of these marked sheep have died; the last two ewes disappeared in the latter part of the winter 1988-1989. The carcass of one of these ewes was found and recovered for analyses. These two ewes had been live-captured and marked during the winter of 1970-1971.

The ewe found was born in May of 1969; she would have been 20 years old had she lived two more months. Her skull is deposited in the collection of Kluane National Park. The other ewe, whose carcass was not located, was also 19 or 20 years of age. In our annual assessments of winter mortalities in this herd, we have located several ewes that died at 15 or 16 years, but none previously that reached 19 or 20 years.

In the MacKenzie Mountains of the Northwest Territories, 101 ewes were randomly collected in 1971-1972. They included two 12-year-old ewes (Simmons et al. 1984). In Mt. McKinley National Park, Alaska, Murie (1944) inspected 221 sheep that died during the period 1937 to 1941, as well as 608 sheep that died in the park prior to 1937. These included three 14-year-old rams and four 12-year-old ewes. Hemming (1969) reported two 15-year-old females and a 14-year-old male in 129 Dall sheep collected in the Brooks Range of Alaska. During the years 1968 to 1971 over 338 Dall Sheep were captured in nets and 204 were marked, including two 12-year-old ewes from the Dry Creek sheep population, and two 16-year-old ewes from the Crescent Mountain herd in Alaska (W. E. Heimer, 1982. Interior sheep studies, W-17-8 to W-21-1. Alaska Department of Fish and Game, Juneau, 52 pages).

Although our marked animals exceed these records by over four years, conventional techniques of aging sheep by means of the horn annulus techniques are not very reliable for old ewes (Hoefs and König 1984). Using the horn annulus technique here, the inspected ewe would have been aged at 18 instead of 20 years.

Both these marked ewes had lambs during the 1987 summer and one of them had a lamb during the 1988 summer. It is not known whether the ewe recovered was pregnant at death since the carcass was largely consumed by coyotes. Our experience, however, is that old age does not lower productivity; an observation supported by other Dall Sheep studies (Simmons et al. 1984; Heimer *unpublished*: citatation above).

The ewe discussed showed aberrations of the tooth arcade and mandible due to a disease which is fairly common in Dall Sheep and thought to be caused by the bacteria *Corynebacterium pyogenes* (Glaze et al. 1982; Simmons et al. 1984; Murie 1944). Figure 1a and b shows vertical and lateral photographs of the infected jaw. The cheek teeth show uneven wear and displacement; PM_2, PM_3, PM_4, and M_1 on the left are missing. All incisors are present. In spite of its prevalence and the apparent handicap this problem must impose on the affected sheep, we have no evidence from our sample (n = 831) that either longevity or productivity are influenced by it.

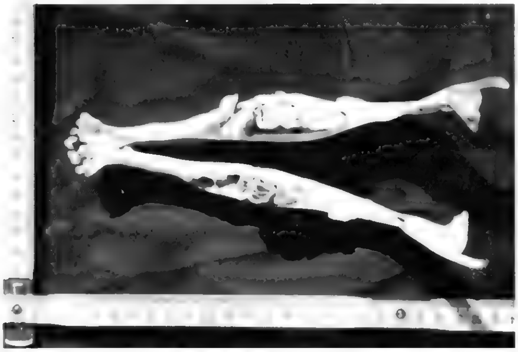

FIGURE 1a. Vertical photograph of the infected lower jaw of ewe aged 19+ years. Collection of Kluane National Park.

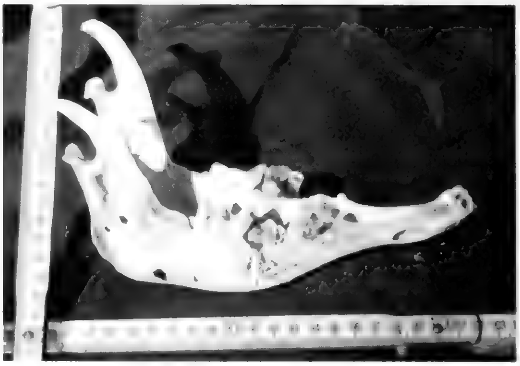

FIGURE 1b. Lateral photograph of the infected lower jaw of the same ewe.

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Additional Vertebrate Prey Items of the Red Squirrel, *Tamiasciurus hudsonicus*

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I observed Red Squirrels with two previously unreported vertebrate prey items: an adult male American Goldfinch (*Carduelis tristis*) and a Tiger Salamander (*Ambystoma tigrinum*).

Key Words: Red Squirrel, *Tamiasciurus hudsonicus*, prey items, aspen parkland, Manitoba, American Goldfinch, *Carduelis tristis*, Tiger Salamander, *Ambystoma tigrinum*.

Animal foods are relatively uncommon in the diet of Red Squirrels (Layne 1954), they have long been known to take vertebrate prey, especially flightless young birds (Thoms 1922; Dobos 1986). However, I found no published reports of Red Squirrels killing either adult birds capable of flight or amphibians. Here I report both.

My observations were made at the Minnedosa substation of the Delta Waterfowl and Wetlands Research Station, 8 km southeast of Minnedosa in

southwestern Manitoba, Canada (50°06'N; 99°50'W). The 65-ha study site lies within the aspen parkland biome, and consists of a mosaic of forest, diverse wetland types, cultivated cropland, and open yard fringed by seasonally-occupied human dwellings. The study site contains a 30-ha woodlot, the largest within 8–10 km. The upland portion of the woodlot is dominated by Quaking Aspen (*Populus tremuloides*), Bur Oak (*Quercus macrocarpa*), and Box Elder (*Acer negundo*); several White Spruce (*Picea glauca*) were introduced near the dwellings. Willows (*Salix* spp.) dominate in low areas and wetland fringes. Birdseed was supplied to wildlife in several feeders annually in spring. Several species of songbirds and one or more Red Squirrels (primarily males) frequently fed at these.

On 23 May 1986, I observed a Red Squirrel attack and kill a male American Goldfinch from a flock of goldfinches on a feeder fastened to a tree two meters above the ground. The squirrel approached the tree from the ground, climbed to the feeder on the opposite side of the tree trunk, and rushed in on the flock. The squirrel carried the goldfinch to the ground and deposited it at the base of the tree. It left the vicinity of the feeder and did not return within 10 minutes, so I retrieved and inspected the bird. The goldfinch seemed to be in good physical condition. I found subcutaneous hemorrhaging in its left thoracic region; it appeared to have died from internal injuries.

On 10 August 1987, I observed a Red Squirrel carrying a dead Tiger Salamander by the head/neck region up into a White Spruce tree. The squirrel was lost from sight in the tree canopy, and I do not know if the salamander was consumed. No sign of the salamander was subsequently found near the tree. The day was cool and overcast with a light drizzle; many Tiger Salamanders were observed moving about the uplands on the study site. Tiger Salamanders would have been an abundant prey item on that date, and I suspect that the squirrel killed the salamander rather than scavenged it.

My interpretation of the first incident is that the squirrel killed the goldfinch in defense of a food source, rather than for consumption. Birds usually left the feeder as Red Squirrels approached, but this flock of goldfinches seemingly was caught unaware. Layne (1954) observed Red Squirrels defending small areas surrounding feeding stations from conspecifics; perhaps this behavior extends to other animals in unusual circumstances. In the second incident, the salamander probably was encountered opportunistically while the squirrel foraged. Because the squirrel transported the salamander up into a tree, it seems likely that it intended to consume it.

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Distribution of the Mudpuppy, *Necturus maculosus*, in Minnesota in Relation to Postglacial Events

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The Mudpuppy, *Necturus maculosus*, dispersed through Minnesota from a Mississippi River refuge following deglaciation and now inhabits drainages physically isolated from that river system. Access to the Hudson Bay drainage was provided by drainage from glacial Lake Agassiz through the River Warren, following the course of the present Red and Minnesota rivers. Access to Lake Superior was available through several routes, but most directly by drainage of meltwaters through the valleys of the present Brule and St. Croix rivers. There are no confirmed records of the Mudpuppy in the Mississippi River above St. Anthony Falls. Routes for colonizing that region were temporarily available both early and later during the postglacial period. Finally, whether or not the Mudpuppy occurs above barrier falls in tributaries to Lake Superior's North Shore has a bearing on interpretations of its postglacial dispersal.

Key Words: Mudpuppy, *Necturus maculosus*, biogeography, dispersal, geographic distribution, Pleistocene, glaciation, Minnesota.

The Mudpuppy, *Necturus maculosus*, a completely aquatic salamander, repopulated the Upper Midwest following deglaciation by moving northward up the Mississippi River (Hecht and Walters 1955; Vogt 1981; Stewart and Lindsey 1983), but today it is found in bodies of water that it could no longer reach from the lower Mississippi River. The purpose of this note is to review and explain the distribution of *N. maculosus* in Minnesota on the basis of previously published analyses of fish dispersal routes (Underhill 1957; Bailey and Smith 1981) and recent geological advances (Hobbs 1983). In addition, critical geographic areas for future sampling are identified.

Minnesota is divided into three drainages today physically separated by land masses: the Mississippi River, Hudson Bay (Red and Rainy rivers), and Great Lakes (Lake Superior) drainages (Figure 1). The Mississippi River drainage is further divided by St. Anthony Falls at Minneapolis. St. Anthony Falls was a barrier to upstream dispersal by aquatic organisms until its recent replacement by a lock and dam, whereas the Mississippi River below the falls is considered to have always been physically continuous with its major tributaries in Minnesota, the Minnesota and St. Croix rivers (Underhill 1957).

The present distribution of *N. maculosus* in Minnesota includes the Mississippi River, St. Croix River, Minnesota River, Hudson Bay, and Lake Superior drainages (Breckenridge 1944; Hecht and Walters 1955; Gilderhus and Johnson 1980; Stewart and Cochran 1980; Cochran and Mueller 1983; Cochran 1987; Moriarty 1987; B. L. Oldfield and J. J. Moriarty, Amphibians and reptiles native to Minnesota, Minnesota Department of Natural Resources, *in preparation*). A problematic area is the Mississippi River drainage above St. Anthony Falls; the single record in Breckenridge (1944) is questionable in several respects (Figure 1). The corresponding catalog entry in the Bell Museum of Natural History (University of Minnesota, Minneapolis) provides no indication of who collected the specimen or in what body of water. The only locality information is Osage (Becker County), which is near the Mississippi-Hudson Bay divide. The specimen was taken from the stomach of a pike on 30 May 1935, but a catalog entry dated 24 May 1948 indicates that the specimen was lost. Misidentification of a partially digested larval *Ambystoma tigrinum* or importation as bait cannot be excluded.

Negative evidence supports the working hypothesis that *N. maculosus* is absent from above St. Anthony Falls. Because, in the words of Underhill (1986), "presence is more easily and convincingly proven than absence," negative evidence of the type presented here is of value only to the extent of the sampling effort that it represents. *Necturus maculosus* was not collected during a number of biotic surveys of the Mississippi River or its tributaries above St. Anthony Falls (Hopwood 1974; Enblom 1977; Kucera and Heberling 1977; Kucera and Peterson 1980), all of which included fish collections and at least some consideration of reptiles and amphibians. Neither has it been collected there by James Underhill, who has observed it in other drainages (Underhill, personal communication). Finally, *N. maculosus* is collected regularly on the cooling water intake screens of power plants along the Mississippi River below St. Anthony Falls (e.g., Cochran and Mueller 1983) and in the St. Croix River drainage (Kenneth Mueller, Biologist, Northern States Power Company, personal communication), but it has never been recorded at two simi-

FIGURE 1. Major drainages in Minnesota. The Mississippi River drainage below St. Anthony Falls includes the Minnesota and St. Croix river drainages. The question mark (?) indicates the approximate location for the only published record of *Necturus maculosus* from above St. Anthony Falls (Breckenridge 1944); its occurrence has been documented in each of the other drainages (Oldfield and Moriarty, *in preparation*). Also shown are the former locations of glacial lakes Aitkin and Upham, with inlets and outlets, as discussed in the text. Map modified from those provided by Underhill (1957), Hobbs (1983), and Oldfield and Moriarty (*in preparation*).

lar power plants, Monticello and Sherco, (Sharon Sarappo, Northern States Power Company biologist, personal communication), located along a portion of the Mississippi River above St. Anthony Falls with apparently optimum habitat (abundant boulders and rubble).

Whether or not *N. maculosus* is present in the Mississippi drainage above St. Anthony Falls, it is possible to explain its distribution in Minnesota on the basis of fish dispersal routes proposed by Underhill (1957). Temporary access to the Mississippi drainage above St. Anthony Falls was provided by the Grantsburg sublobe, an extension of glacial ice that diverted the Mississippi River around the subsequent location of St. Anthony Falls through what would become the Lower St. Croix Valley. Access to the Hudson Bay drainage was provided by drainage from glacial Lake Agassiz through the glacial River Warren, following the course of the present Minnesota River. Access to the Lake Superior drainage was available through several routes at various times, but most directly through the present day Brule and St. Croix river valleys.

Barring the possibility of extinction subsequent to colonization, absence from one drainage of aquatic species present in other drainages suggests that access to that drainage was blocked before closure of routes into the other drainages. On this basis, Underhill (1957) suggested that access to both Lake Superior and the Hudson Bay drainage was denied before closure of the route into the Mississippi drainage above St. Anthony Falls. However, a more recent analysis (Bailey and Smith 1981) includes maps which indicate that fish dispersal up the Mississippi River was blocked by St. Anthony Falls before closure of routes into other drainages. If *N. maculosus* is indeed absent only from above St. Anthony Falls, that absence would be more consistent with the latter scenario. At least one fish, *Noturus flavus*, which in many ways is ecologically similar to *Necturus maculosus* (Cochran, unpublished observations), is now known to have a similar distribution (Eddy and Underhill 1974).

More recently, Hobbs (1983) described a drainage sequence by which aquatic organisms may have gained access to the Mississippi River above St. Anthony Falls subsequent to the retreat of the Grantsburg sublobe (Underhill 1989). This involved drainage from Lake Koochiching, an eastern arm of Lake Agassiz, into lakes Upham and Aitkin (Figure 1). The latter drained at various times into the St. Louis, Snake, and Mississippi rivers. According to this scenario it would have been possible for organisms to move from the Mississippi River up the St. Croix River and through the St. Louis or Snake rivers to colonize lakes Upham and Aitkin, then later move down into the Mississippi River above St. Anthony Falls.

A final aspect of the distribution of *N. maculosus* in Minnesota involves its presence in tributaries to the north shore of Lake Superior. Many of these streams pass over falls which are presently barriers to upstream dispersal, and the presence of fishes above these falls is an indication that those species dispersed into the drainage relatively early, before isostatic rebound and falling lake levels brought the barriers into effect (Underhill and Moyle 1968). Although *N. maculosus* has been reported in Lake Superior tributaries treated with lampricides to control the Sea Lamprey (*Petromyzon marinus*) (Gilderhus and Johnson 1980), these treatments typically are applied only downstream from barriers. I know of no Mudpuppy records from above barrier falls. On the basis of Bailey and Smith's (1981) chronology, the absence of *N. maculosus* from the Mississippi drainage above St. Anthony Falls would be expected if it arrived in Minnesota too late to disperse above the barriers on Lake Superior tributaries (e.g., if it entered what would become Lake Superior by moving into Lake Minong through its eastern outlet near Sault Ste. Marie).

Mudpuppies are more frequently encountered by fisheries scientists and other aquatic biologists than by herpetologists. These personnel should be alerted to the value of any specimens collected in the Mississippi River drainage above St. Anthony Falls or above the barriers on Lake Superior's North Shore tributaries.

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Factors Influencing Meadow Vole, *Microtus pennsylvanicus*, Distribution in Minnesota

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The distribution of Meadow Voles (*Microtus pennsylvanicus*) was examined in relation to mounds of Plains Pocket Gophers (*Geomys bursarius*) in an old field near Itasca State Park, Clearwater County, Minnesota from June through August 1989. Area occupied by gopher mounds, open space, litter depth, and percent cover of Quack Grass (*Agropyron repens*) were measured in 80 8 x 8 m quadrats. Distribution of voles was determined by mark-recapture live-trapping and by tracking of fluorescent dyed individuals. Male voles showed a significant positive association with new gopher mounds as determined from mark-recapture data. Fluorescent trails left by marked individuals indicated frequent visits to gopher mounds.

Key Words: Meadow Voles, *Microtus pennsylvanicus*, Plains Pocket Gophers, *Geomys bursarius*, distribution.

Plains Pocket Gophers (*Geomys bursarius*) and Meadow Voles (*Microtus pennsylvanicus*) may occupy the same habitat type, such as grass dominated old fields (Hazard 1982; Jackson 1961). In these habitats, both species tend to concentrate in areas of high plant biomass (Reichman and Smith 1985). Food-habits studies of gophers (Behrend and Tester 1988; Williams and Cameron 1986) and voles (Thompson 1965; Lindroth and Batzli 1984; Zimmerman 1965) suggest that the two species may use similar food sources.

Tunneling by pocket gophers reduces plant biomass by direct foraging and by root desiccation from exposure to air within the burrow (Reichman and Smith 1985). As tunnels are dug, soil is pushed up and mounds of bare earth are created. Light conditions and mound soil are well suited for growth of annual plants (Tilman 1983). Mound formation also affects soil nutrient status and secondary successional patterns (Grant and McBrayer 1981).

New mounds lack vegetation, do not provide cover or sources of food, and might be expected to deter voles. Older mounds are likely to have more herb than grass species. Some of these plants may be selected as sources of food by voles, thus increasing the abundance of voles locally.

In this study, we report a relationship between vole distribution patterns and the location of gopher mounds and open areas (areas lacking living grass and characterized by a thick layer of litter).

Methods

The research was conducted on one 0.5 ha study grid in a 2.5 ha old field located near Itasca State Park, Clearwater County, Minnesota. Ninty-nine non-folding galvanized metal live-traps (L. M. Leathers Co., Athens, Georgia) baited with oatmeal were placed 8 m apart in a 9×11 grid. Traps were set on 15 evenings from 13 June through 8 August, 1989 and checked the following mornings. Sex of captured voles was determined, and they were weighed, marked by toe-clipping, and released. Voles weighing 30 g or more were classified as adults.

Capture data were used to determine vole distribution in the study area. The total number of animals using each quadrat was estimated by the sum of the number of animals captured in the four traps on the perimeter of that quadrat. Our determination of vole distribution assumed that individuals caught on a corner of a 8×8 m quadrat used the area in that quadrat.

Voles marked with fluorescent powder (Lemen and Freeman 1985) were tracked to determine precise habitat use. Individuals were selected for tracking if they had been caught at least five times.

Gopher mounds in each quadrat were measured and classified as new (no growth of vegetation) or old (vegetation present but less dense than surrounding vegetation). The abundance of open areas and Quack Grass (*Agropyron repens*) was measured by estimating percent cover in 0.5×0.5 m quadrats within each quadrat. Relations between vole distribution and the area covered by gopher mounds, open areas, and abundance of Quack Grass were examined by product-moment correlation analyses.

Results

During 15 trapping periods in our 56-day study, 505 captures were made of 155 individual voles. Maps were made of 13 trails created by seven adult voles trapped on 1, 5 and/or 8 August (Figure 1). Each trail represents the path traveled during the time the powder dropped from each vole. We believe the time was at least several hours, but have no data on this. Male A and females C, E, and F

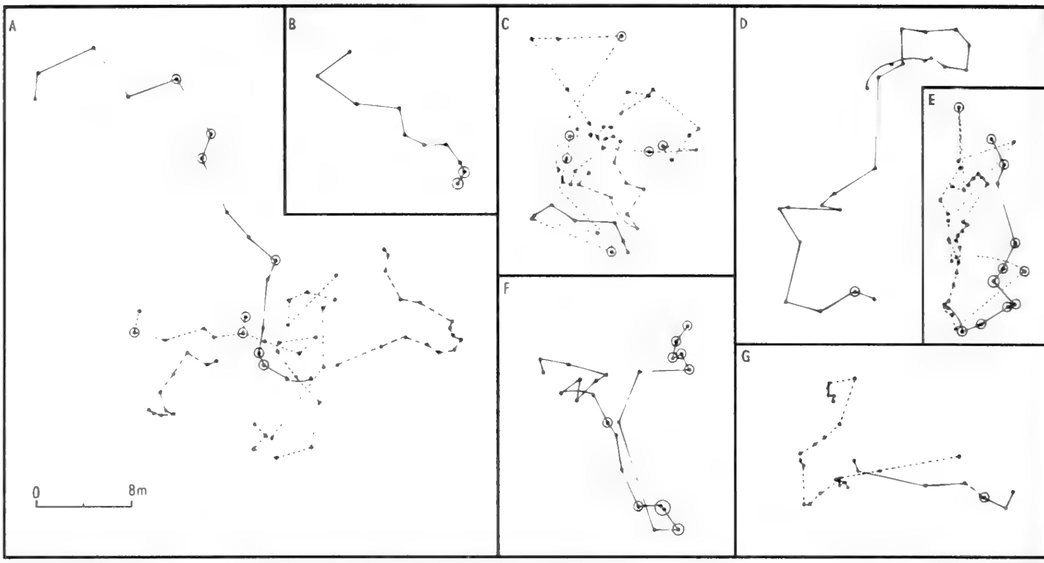

FIGURE 1. Flourescent trails left by seven meadow voles. A and B were adult males; C-G were adult females. Solid circles indicate direction change in path of movement. Open circles show intersections of trails with pocket gopher mounds. Broken lines represent trails for the same individual measured in subsequent tracking periods.

appeared to make heavy use of gopher mounds. However, none used the same mound during different tracking periods. Subsequent observations identified worn trails or runways leading to and from gopher mounds.

Eleven of the 13 fluorescent trails passed over gopher mounds (Figure 1). Multiple paths on some mounds indicated that voles used the mounds as intersections. Plants growing on old mounds were often marked with powder and showed evidence of being eaten. Yellow Dock (*Rumex crispus*) and Hoary Alyssum (*Berteroa incana*) were the most heavily used. Both sexes appeared to use both new and abandoned mounds frequently. Droppings were frequently found on the mounds. Droppings, litter and clippings of vegetation were found in small holes on some old mounds. No signs of actual burrowing into mounds were observed.

Captures of adult males, all males, adult females, all females and all adults, and all individuals were not significantly related to the proportion of the quadrat covered by gopher mounds (both types together) or old mounds alone. Captures of both adult males and all males were significantly correlated with the percent coverage by new gopher mounds (Table 1), but a significant relationship was not observed for females or total individuals. Captures of all males and all individuals were significantly related to the percent coverage by open area (Table 1).

The distributions of all group categories except all males showed a significant positive association with the percent cover of Quack Grass (Table 1). Males appeared to be negatively associated with Quack Grass, but the effect was not significant (Table 1, $p = 0.079$).

TABLE 1. Correlations of number of captures of Meadow Voles with the abundance of new mounds of Plains Pocket Gophers, percent open area, and percent cover of Quack Grass. A total of 155 individuals were captured.

	Number of Captures	New Mounds	Percent Open Area	Percent Quack Grass
Males-Total	606	-0.220**	+0.299**	-0.197
Males-Adult	400	+0.321**	-0.067	+0.270*
Females-Total	1055	0.027	-0.163	+0.348**
Females-Adult	630	0.140	-0.005	+0.377**
Total Voles	1661	0.119	+0.255*	+0.345**
Adult Voles	1030	+0.249*	-0.035	+0.396**

* $p < 0.05$.
** $p < 0.01$; d.f. = 79

Discussion

Male Meadow Voles were significantly positively associated with new pocket gopher mounds. This may have been related to exploration of the new features in their home ranges. Males and total individuals also showed a positive association with open areas. The observed behavior of apparently seeking open areas is possibly related to mating strategies, displaying, foraging, or other behavioral traits. Dense vegetation covering the study plot appeared to provide voles with abundant food and cover. It may be less energetically expensive for voles to travel through open areas and over mounds, thereby circumventing the dense litter. Runways through the litter may not be as direct as traveling in the open. However, travel in open areas may increase the risk of predation. Data concerning the amount of time individuals spend on mounds or in exposed areas throughout the 24-h day are necessary to support further speculation on the source of this behavior.

An alternative explanation for use of the mounds may be linked to the within-habitat distribution of a common food source, rather than to behavioral characteristics. Quack Grass, which was abundant on the study site, is a known food source for both voles (Lindroth and Batzli 1984; Thompson 1965; Zimmerman 1965) and pocket gophers (Behrend and Tester 1988; Grant and McBrayer 1981). Mounds may have been more common in or near dense Quack Grass stands and the voles may have been responding to the food source rather than the presence of mounds. However, association with these patches of vegetation would not necessarily require travel directly on gopher mounds.

Use of Yellow Dock and Hoary Alyssum, which were common on old mounds, may have been related to food or moisture. These two species remained succulent throughout August, when we conducted our fluorescent tracking studies; at this time, grasses in the field appeared dry and senescent. Voles may have used these plants to fulfill water requirements.

We conclude that Meadow Voles are attracted to pocket gopher mounds. However, we do not know whether the attraction is related to food, a behavioral component, or both.

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Chick Fostering by Common Loons, *Gavia immer*

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An unsuccessful breeding pair of Common Loons (*Gavia immer*) successfully fostered an unrelated chick.

Key Words: Common Loon, *Gavia immer*, fostering, Wisconsin.

Fostering of young birds by unrelated adults of the same species has been reported to occur naturally in several waterfowl species (Bennett 1938; Mendall 1958; Beard 1964) and has been artificially induced in raptors (Engel and Isaacs 1982; Evans 1982). Eckstein (1980) reported fostering of a Common Loon (*Gavia immer*) chick by an adult Common Loon pair with a chick of approximately the same age. We report on the successful fostering of a Common Loon chick by an unsuccessful breeding pair of Common Loons.

On 16 June 1987, an abandoned Common Loon chick was brought from a nearby lake to Wisconsin Department of Natural Resources personnel in Mercer, Iron County, Wisconsin. The plumage of the chick was transitional between Stage A and Stage B down (Palmer 1962) which would place the chick at approximately 10–14 days of age (McIntyre 1988). Three unsuccessful attempts were made to return the chick to the adults. We then transported the chick to Trude Lake, Iron County (46°10'N; 90°10'W). Trude Lake is 309–ha and typically contains two territorial loon pairs (J. F. Olson, unpublished data). The pair on the West portion of Trude Lake had successfully hatched one chick, while the pair on the East portion of Trude Lake had constructed a nest and laid two eggs but the eggs had been depredated or abandoned and scavenged.

At 2000 hrs on 16 June 1987, the chick was released approximately 90 m from the East Trude Lake pair. The adults immediately tremeloed several times and dove to within 30 m of the chick. The adults tremeloed again and swam toward the chick; the chick began peeping. At 2003 hrs, the chick climbed onto the back of one of the adults. The group was observed until 2109 hrs. The chick spent approximately 30% of this time on the back of an adult and was successfully fed two small fish (≤5 cm). The group was observed weekly for 3-hour intervals until the chick was approximately six weeks old. The chick was fully accepted by the adult pair and was last observed with the adults on 25 August, 70 days after release. The chick was approximately 80–84 days old, the age at which flight is possible (McIntyre 1988).

Based on findings presented here and those of Eckstein (1980), we conclude that adult breeding Common Loon pairs will accept and foster chicks ≤14 days old. Limited banding data suggest that adult Common Loons display territorial fidelity (McIntyre 1974; Eberhardt 1984; Belant et al. 1991). Additionally, Eberhardt (1984) reported recapturing a juvenile loon on the same lake on which it was raised. If fostered chicks return to the area of adoption rather than their natal area, fostering of chicks by unsuccessful breeding Common Loons may prove a valuable mechanism for re-establishing loon numbers in areas where populations have declined, once the cause for the decline has been corrected.

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A New Stranding Record of the Pygmy Sperm Whale, *Kogia breviceps*, in Waters off Eastern Canada

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Nelson, D., A. Desbrosse, J. Lien, P. Ostrom, and R. Seton. 1991. A new stranding record of the Pygmy Sperm Whale, *Kogia breviceps*, in waters off eastern Canada. Canadian Field-Naturalist 105(3): 407–408.

A male specimen of the Pygmy Sperm Whale (*Kogia breviceps*) was collected from the French Island of Miquelon (46°58'N, 56°19'W) on 8 October 1989. Measurements were taken, and an analysis of $\partial^{15}N$ in the muscle tissue indicated that it had probably been feeding on offshore squid. The $\partial^{13}C$ value for the specimen was typical for a marine, plankton-based system.

Key Words: Pygmy Sperm Whale, *Kogia breviceps*, stranding, Miquelon, $\partial^{15}N$, ∂13 C

The Pygmy Sperm Whale is a small cetacean belonging to the same family (Physeteridae) as the Sperm Whale *Physeter macrocephalus*. Little is known about the species, as information about its distribution, abundance, and behaviour have come mainly from stranding records and a few sightings at sea. It is known to occur in all tropical and temperate oceans (Handley 1966), and has been reported to be the second most common stranded cetacean along the coasts of the southeastern United States (Leatherwood and Reeves 1983).

Only two records of strandings in Canada exist: a dead female was found under ice on 17 January 1920 in Halifax, Nova Scotia (Piers 1923), and a specimen was discovered on Sable Island off the coast of Nova Scotia in January 1969 (Sergeant 1970). Individual specimens have also been found stranded near Canada on the outer Washington State coast in May 1942; Whidbey Island, Washington in October 1977; and at Port Angeles, Washington in June 1985 (Osborne, Calambokidis, and Dorsey 1988).

In early September 1989, a male Pygmy Sperm Whale was discovered stranded on the coast of the French Island of Miquelon (46°58'N, 56°19'W) near the Newfoundland coast (Figure 1). Species identification was confirmed by body length and tooth count. The specimen was examined and collected on 8 October 1989 by which time it was badly decomposed. Tissue samples for isotope analysis were collected and measurements were taken (Table 1). The skeleton is now preserved at the Canadian Museum of Nature (specimen number 52 618).

The right side of the lower jaw had fourteen teeth while the left side had thirteen teeth. No erupted teeth were found on the upper jaw. Judging from the size of the penis the specimen may have been mature.

An analysis of muscle tissue from the specimen yielded a $\partial^{15}N$ of 11.9, which is similar to the $\partial^{15}N$ of 11.1 obtained from the muscle tissue of a Sperm Whale. This probably indicates that both specimens were feeding on offshore squid. The $\partial^{13}C$ value for the Pygmy Sperm Whale was 18.2, which is typical for a marine, plankton-based system.

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FIGURE 1. Pygmy Sperm Whale, *Kogia breviceps*, collected from the coast of Miquelon in October 1989.

TABLE 1. Measurements of a Pygmy Sperm Whale, *Kogia breviceps*, collected from Miquelon in October 1989.

Measure	Size (mm)
Tip of lower jaw to anterior insertion of right pectoral	480
Tip of lower jaw to posterior insertion of right pectoral	615
Tip of lower jaw to anterior insertion of left pectoral	470
Tip of lower jaw to tip of right pectoral	815
Tip of lower jaw to gape of mouth	230
Tip of lower jaw to center of eye	325
Tip of lower jaw to notch of flukes	2315
Anterior insertion of right pectoral to tip	335
Width at insertion	150
Posterior edge at insertion to tip	265
Maximum width	120
Anterior insertion of left pectoral to tip	330
Width at insertion	140
Maximum width	120
Right insertion of flukes to tip, bottom measure	380
Left insertion of flukes to tip, bottom measure	390
Maximum width of flukes	670
Maximum width from notch, right	200
Maximum width from notch, left	200
Maximum length of penis	340

ing the skeleton; and Robin Baird for help with the literature.

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Observations of Vehicle Traffic Interfering with Migration of Dall's Sheep, *Ovis dalli dalli*, in Denali National Park, Alaska

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Dalle-Molle, John, and Joseph Van Horn. 1991. Observations of vehicle traffic interfering with migration of Dall's Sheep, *Ovis dalli dalli*, in Denali National Park, Alberta. Canadian Field-Naturalist 105(3): 409–411.

Two observations of Dall's Sheep groups unsuccessfully attempting to cross the Denali National Park Road, during a seasonal migration, are described. Where the road passes through sheep range, sheep have habituated to the traffic and readily cross. Sheep occupying ranges away from the road must cross the road during seasonal migrations and have not habituated to traffic, even though the road has been there for 54 years.

Key Words: Dall's Sheep, *Ovis dalli dalli*, traffic, road, habituation, Denali National Park.

The reactions of wildlife to human activities and development have been a growing concern in recent years (see Bromley 1984; Geist 1975; and Shank 1979 for reviews), but we were unable to find any studies of the effects of vehicle traffic on Dall's Sheep (*Ovis dalli dalli*) migration. A few observations of successful road crossings and unsuccessful attempts by migrating Dall's Sheep were reportd by Tracy (1977) for the park road in Denali National Park (DENA). Here we provide additional observations of responses of migrating Dall's Sheep to vehicle traffic along the DENA Road.

The DENA park road, built in 1936, is a 130 km primarily gravel road (the first 21 km are paved) that follows a series of intermontane fault valleys from the park entrance to the Kantishna mining district. The road is closed, because of snow, from late September to early May. During the remainder of the year, traffic is limited to shuttle/tour buses for park visitors (established in 1973 to minimize traffic on the road), a limited number of private vehicles, and National Park Service vehicles.

In DENA, Dall's Sheep migrate to summer range in June and back to winter range in September across a fault valley in the eastern end of the park that is 3 to 10 km wide. The park road is situated in this valley and is therefore traversed on these annual migrations (Murie 1944; Singer and Beattie 1986). Traditional migration routes cross the valley as visible trails that extend up to 10 km between areas of escape terrain for sheep. Where the road cuts across steep slopes, sheep have habituated to traffic and human activities and tolerate vehicles and people within a few meters (Singer and Beattie 1986). Sheep are most often observed crossing the road in these areas. Sheep have not habituated to traffic in areas where the road is 1 km or more from their seasonal ranges and are wary when they approach the road. We reviewed wildlife observation records in the park files, and found 28 observations of sheep near the road in such areas, including 8 cases of unsuccessful attempts by sheep to cross the road.

Observations

On 19 June 1985, we drove across lower Hogan Creek at 1012 h, an area 1.5 km from sheep range. We observed a group of seven ewes and one yearling 300 m to the west where a visible migration trail crosses the road. We immediately stopped and observed their behaviour, aided with 7X binoculars, and took notes. The sheep were approximately 200 m upslope from the road, on a 35% slope covered by dense Dwarf Birch (*Betula nana*), willow (*Salix* spp.) up to 1 m high, and scattered clumps of White Spruce (*Picea glauca*). When first observed, the sheep were stationary, oriented toward the road, and displaying attention postures (Geist 1971). At 1015 h, they began slowly moving downhill toward the road. At 1020 h, the sheep hesitated 100 m from the road and remained alert. At 1021 h, they resumed moving toward the road pausing at about 75 m. At 1022 h, they moved rapidly to a dense 3 m high willow clump 25 m from the road.

The sheep were still in the willows and not visible at 1030 h when a westbound car went by. At 1033 h, the sheep walked out of the tall willows and retreated upslope about 50 m. A westbound shuttle bus stopped at our location, still 300 m from the sheep, and the group of sheep broke into a full run uphill for 200 m. At 1035 h, the bus left, driving below the sheep, and they walked upslope an additional 50 m, and were now 300 m above the road. During the next 5 minutes, three trucks and two cars passed by as the sheep slowly continued walking upslope. At 1043 h, the sheep stopped 500 m from the road and looked toward it. At 1046 h, two sheep walked downslope about 10 m but a truck and a car pulling a house trailer passed by and the two sheep rejoined the others. Another truck went by at 1048 h, while the sheep continued looking toward the road. At 1049 they resumed walking upslope away from the road. By 1120 h, 50 minutes after their closest approach to the road, the sheep had returned to the escape terrain within their usual winter range, 1.5 km from the road.

On 15 June 1983, two park wildlife technicians observed four ewes attempt to cross the park road a few kilometers west of the above location. Terrain, vegetation, and distance to sheep range were similar to the last location. At 1032 h, the ewes were observed 60 m from the road in a predominantly willow and dwarf birch area. They were moving parallel to the road occasionally stopping to stand or running and jumping. They continued for 200 m while a truck and car drove by slowly. The sheep reversed direction, but the car and truck backed up to keep the sheep in sight. At 1050 h, the sheep again changed direction and went 100 m with the truck following them. The sheep stayed about 60 m from the road, alternately walking and standing alert as several vehicles passed by. They moved an additional 10 m from the road when a shuttle bus arrived and stopped. The bus left at 1108 h, and after staring at the road while four vehicles passed and two stopped, the sheep bedded down. At 1120 h, a bus arrived and the engine backfired. The sheep immediately jumped up and ran 300 m to a ridge. At 1145 h, when the observers left, the sheep were 400 m from the road and looking alertly toward the road.

Discussion

There are many accounts of wild sheep apparently habituating to familiar and frequent vehicle traffic, for such behaviour is readily noticed (Graham 1980; MacArthur et al. 1982; Singer and Beattie 1986; Tracy 1977). Evidence of intolerance or avoidance of areas with human activity may be less easily accumulated since there may be confounding explanations of such animal responses (Graham 1980; Singer and Beattie 1986).

The observations we have reported support the hypothesis that animals occupying areas distant from human activities are less likely to habituate, since contact is rare. These observations were of Dall's Sheep trying to cross a road that is more than 1 km from their usual seasonal ranges and escape terrain. These sheep were not exposed to frequent, predictable contact with vehicles. Krauseman and Leopold (1986) observed Desert Bighorn (Ovis canadensis nelsoni) ewes that reduced their movements by 96% after a road was constructed that bisected their range. From our review of park files, it appeared that Dall's Sheep, initially thwarted from crossing the park road, were eventually successful after repeated attempts. However, they were subjected to considerable stress and time away from more secure habitats. Predation on sheep was reported on three occasions near the park road. In one case, it was apparent that a ram had been prevented from crossing the road and was attacked by wolves. In the other observations it is unclear whether traffic inhibited the movements of the sheep.

Interference with migration can cause many problems for mountain sheep. Delayed or abandoned spring migrations can place additional grazing pressure on winter ranges. Forage quality and quantity on winter range during summer may be less than on summer range (Hebert 1973). Sheep forced to remain on winter range may therefore grow less, be in poorer condition for the coming winter, and suffer reduced productivity. In time, migration patterns may be lost with consequent loss of range (Bailey 1986). Movement delays and repeated crossing attempts expose sheep to mortality from vehicle strikes and predation, as well as having energetic costs (Geist 1978).

Future studies of the effects of developments and human activities should evaluate the importance of these problems for nonhabituated wildlife. Planning, design, and management of roads (including traffic volume, frequency, and speed) should take into account the behavior of wildlife populations, and consider ways to improve habituation or reduce disturbances.

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Première mention de la Tortue musquée, *Sternotherus odoratus*, au Québec

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Charbot, Jacques, et Daniel St-Hilaire. 1991. Première mention de la Tortue musquée, *Sternotherus odoratus*, au Québec. Canadian Field-Naturalist 105(3): 411–412.

On rapporte les premières mentions de la Tortue musquée (*Sternotherus odoratus*) au Québec. Un premier spécimen a été capturé le 17 août 1989 dans l'émissaire de la baie McLaurin, à Gatineau et six autres individus à 3,5 km au sud-ouest de Bristol-les-Mines, les 12 et 14 septembre 1990, en bordure de la rivière des Outaouais.

The first record of the Stinkpot, *Sternotherus odoratus*, for Quebec is reported. The first specimen was captured 17 August 1989 in the outlet of McLaurin Bay, Gatineau. Six additional individuals have been found 12 and 14 September 1990, 3.5 km southwest of Bristol-les-Mines, which borders the Ottawa River.

Mots clés: Tortue musquée, *Sternotherus odoratus*, nouvelle mention, Québec.

La Tortue musquée (*Sternotherus odoratus*), de la famille des Kinosternidés, se rencontre dans l'est des États-Unis ainsi que dans le sud de l'Ontario (Conant 1975). Cook (1981) et Brunton (1981) rapportent sa présence à 5 endroits différents à l'ouest et au sud d'Ottawa, soit à Kemptville (Becketts Landing, Musée canadien de la Nature (NMC) 3938) et à Manotick sur la rivière Rideau, à Carleton Place et à Pakenham sur la rivière Mississippi (NMC 1377 and 14044, oeufs) ainsi qu'à Innisville au lac Mississippi (NMC 2157). D'autres individus furent raportés en juin 1987 à Ottawa, dans la rivière Rideau (Carleton University: Jeff Rennock) et en été 1966 dans la rivière des Outaouais (Rockcliffe Rifle Range: Stephen Darbyshire: (Musée canadien de la Nature, fishes d'observations herpétologiques). Bider et Matte (1990) ne rapportent pas cette espèce pour le Québec; nous faisons état ici de la première mention pour ce territoire.

Un spécimen mâle fut capturé le 17 août 1989 à l'aide d'un verveux à mailles étirées de 45 mm, dans; l'émissaire de la baie McLaurin (45°29'55"N, 75°33'10"O) à Gatineau (comté de Hull). Cette pêche s'inscrivait dans le cadre d'une étude qui visait à connaître les différentes espèces de tortues dans ce secteur ainsi que leur abondance relative, dans un but de mise en valeur et de protection des habitats fauniques importants présents le long de la rive nord des rivière des Outaouais.

L'émissaire de la baie McLaurin est doté d'un courant presque nul de sorte qu'on y trouve un complexe de terres humides composées principalement, selon les définitions de Jacques et Hamel (1982), d'herbiers aquatiques et de marais peu profonds à émergentes à feuilles larges.

Au site de capture, l'émissaire a une largeur approximative de 60 m et une profondeur maximale de 60 cm. Les espèces végétales aquatiques dominantes sont *Elodea canadensis, Hydrocharis morsus-ranae, Sagittaria latifolia, Nymphaea odorata* et *Potamogeton epihydrus*. Le lit de l'émissaire est constitué d'un substrat vaseux. Le verveux était installé dans la zone libre de végétation aquatique émergente, d'une largeur d'environ 10 m, où la profondeur atteignait 60 cm. On y avait capturé également une Chélydre serpentine (*Chelydra serpentina*) et une Tortue peinte (*Chrysemys picta marginata*), ainsi que plusieurs espèces de poissons tels *Esox lucius, Ictalurus nebulosus, Micropterus dolomieui, Pomoxis nigromaculatus, Lepomis gibbosus, Ambloplites rupestris* et *Perca flavescens*.

Des pêches subséquentes effectuées à l'aide de 6 à 9 verveux durant 19 nuits, de 20h00 à 6h00, entre le 16 août et le 11 septembre 1989, n'ont pas permis de capturer un autre spécimen de *Sternotherus odoratus*. Par contre, 124 individus différents de Tortue peinte et 10 de Chélydre serpentine ont été capturés à cette occasion. Ceci indiquerait la rareté relative de la Tortue musquée dans ce secteur.

Le spécimen capturé était un mâle adulte dont les dimensions et la masse étaient les suivantes: longueur de la carapace: 116 mm; largeur de la carapace: 84 mm; longueur du plastron: 83 mm; largeur du plastron: 68 mm; masse: 221,0 g.

Le Ministère au Loisir de la chase et de la pêche a capturé six autre spécimens de *Sternotherus odoratus* à 3.5 km sud-ouest de Bristol-les-Mines (45°29'15"N, 76°23'15"O; comité de Pontiac) les 12 et 14 septembre 1990, à l'intérieur d'une baie parsemée d'une végétation aquatique, sur la rive nord de la rivière des Outaouais, beaucoup plus à l'ouest de la localisation précédente.

Parmi les caractères variables mentionnés par Conant (1975) on a noté la présence de deux bandes jaune vif sur la tête et le cou, une carapace de couleur brun foncé et un plastron de couleur jaunâtre. Les photocopies sous differents angles ont été prises et donné à le Musée canadien de la nature.

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News and Comment

John Dalle-Molle, 1939–1990*

In 1985, I was fortunate to begin a five-year friendship and working relationship John Dalle-Molle, a self-trained naturalist of the highest caliber and a man with strong convictions that guided his professional activities. John was a true "friend" of resources he managed and a strong and active supporter of ecological research. During his tenure at Denali National Park, John made many contributions to natural resource management and facilitated contributions made by many others. I cherish the time I worked with him and certainly miss him since his premature passing.

John was born in 1939 in Chicago. He received a B.A. in philosophy from American Catholic University in the late 1960s. John had a strong fascination with the northern reaches of the continent and travelled extensively through Canada and Alaska during his college years and those that followed. He began working for the U.S. National Park Service (NPS) in the late 1960s and was hired to the permanent staff in 1976 as a ranger at Mt. Rainier National Park in Washington state. There he was well known for his abilities as a climbing ranger and he supervised many technical mountain search and rescue activities during his tenure at Rainier.

In 1978, John accepted the position of Resource Management Specialist at Mount McKinley National Park (now Denali National Park and Preserve) in Alaska where he worked until 1989. John arrived at Mount McKinley at a time when use of the park was expanding dramatically following the opening of a highway between Anchorage and Fairbanks that went right by the park's front gate. In a few years, the park changed from a sleepy out-of-the-way place to the easily accessible, primary destination of most tourists travelling to Alaska. It was a time of great changes in park operations and required the most out of everyone, particularly the resource management specialist. John was the right man for the job.

For those unfamiliar with the NPS, resource management specialists are resource "jack-of-all-trades" expected to have a working knowledge of all facets of resource management that a particular park is faced with. In Denali, a resource manager must be a combination wildlife biologist, plant ecologist, fire effects specialist, geologist/mining engineer, anthropologist, sociologist, and historian at a minimum. John took to the job, and though not formally trained in any resource management field, became well-known and respected for his contributions.

John became a prime player in understanding and managing bear-human interactions in wilderness settings and developed a bear management program at Denali that is innovative and successful. John inherited a bear-human situation with increasing numbers of people in the backcountry and Grizzly Bears used to taking food from people in a wide-open tundra environment where securing food in trees was out of the question. John helped develop backpackable bear-resistant food containers and put them to use in Denali. He also developed an innovative approach to aversive conditioning of problem bears in the field. These efforts have been successful in minimizing the removal of problem bears from the park and therefore man's influences on this naturally regulated bear population.

John also took a strong interest in wildlife-vehicular traffic interactions. Denali National Park put a shuttle bus system in place and began restricting private vehicle access in the early 1970s. With greatly increasing demands on the park's shuttle buses, it was important to evaluate the effects of road traffic on wildlife to aid park managers with difficult and controversial decisions about traffic restrictions. John was instrumental in getting research initiated as well as keeping records of wildlife-traffic interactions, like those reported here.

John made many other contributions to resource management. He was actively involved in wildfire management planning, documenting historic and ongoing subsistence uses of park areas, management and restoration of mining activities in the park, evaluating wilderness uses and backcountry impacts, and monitoring the park's wildlife populations. During his time at Denali, he published over 25 papers on resource related issues. Moreover, he was in charge of overseeing a complex mix of management and research activities and did an incredible job of making order out of chaos.

In 1989, John transferred to North Cascades National Park, Washington, so that he could get medical care that was unavailable in Alaska. He remained actively involved in resource management activities both at Denali and North Cascades. In his

*See: Observations of vehicle traffic interfering with migration of Dall's Sheep, *Ovis dalli dalli*, in Denali National Park, Alberta by John Dalle-Molle and Joseph Van Horne, Canadian Field-Naturalist 105(3): 409–411.

last months, he compiled information on equipment and techniques used throughout North America for bear-human management and brainstormed with me over ways to further monitor interactions between Dall's sheep and road traffic in Denali.

John died in early June 1990. Those of us who worked along side him at Denali will always remember his enthusiasm and the unending support he provided so we could do our jobs. I truly feel honored to have shared a period of my professional career with him.

LAYNE G. ADAMS

National Park Service – Alaska Region; 2525 Gambell Street, Room 107; Anchorage, Alaska 99503

13 March 1991

William F. Davis, 1926-1991

It is with deep regret that I note here the death in a traffic accident of William F. Davis, M.D., of Kingsville, Ohio, 3 January 1991. Dr. Davis had carried on a lively correspondence with me about *The Canadian Field-Naturalist* content from the point of view of a keen naturalist-reader of the journal, always urging terminology that was readily understandable to the educated generalist, and sharing examples of the editorial policy of other publications and responses of their editors.

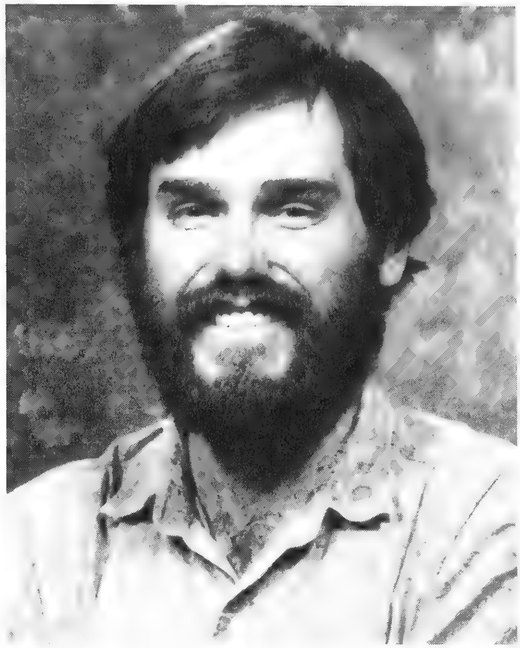
Dr. Davis was born 3 April 1926 and was a veteran of the U.S. Army. He earned a B.Sc. in Science (with honors) in wildlife management from Michigan State University in 1949 where he was a member of the PHI KAPPA PHI honor society. He earned his M.D. from Ohio State University in 1955 and was a staff surgeon at Ashtabule County Medical Center for 30 years. He was a member of the American Medical Association and the Ohio State Medical Association. Dr. Davis was an avid outdoorsman who maintained an active interest wildlife management, birds, mammals, botany, and horticulture and was a member of many professional societies in these fields.

He had contributed to our journal (1953. Birds observed on a canoe trip in northern Manitoba. *Canadian Field-Naturalist* 67(4): 148–159) based on field notes taken primarily from Norway House to York Factory from 8 June to 18 June 1951 when he followed much of the route taken by Edward A. Preble in 1900. In it, he was particularly interested in possible changes in the avifauna over the half century which had elapsed between their ventures.

I will miss the sharp and good-humoured commentary, both critical and supportive, which was representative of the demanding naturalists who help maintain *The Canadian Field-Naturalist* and natural history societies across this continent. I extend my sympathy to his widow, Mrs. Patricia M. Davis, Kingsville, Ohio, to whom I owe thanks for details on Dr. Davis's background, and to his former secretary Theresa Ludwigsen, who forwarded these to me in response to my request.

FRANCIS R. COOK
Editor

George E. Menkens, Jr., 1957-1990*



Dr. George E. Menkens Jr., 33, was lost on 11 October 1990 along with fellow U.S. Fish and Wildlife Service biologist, John Bevins, 35, and pilot, Clifford Minch, when they failed to return from a research flight to monitor radio-tagged polar bears over the Arctic icecap. An exhaustive search began several hours after the plane was reported overdue at their Point Barrow, Alaska departure site. On 25 October, official efforts by the U.S. Coast Guard and U.S. Fish and Wildlife Service were terminated. No emergency signals or other radio communications were received from the aircraft following its departure from the airport. It is thought that the plane went down in open water.

Dr. Menkens grew up in the Hudson River community of Central Valley, New York. He earned a Bachelor of Science degree in forestry at Syracuse University in 1979, then went on to receive Master's and Ph.D. degrees in zoology and physiology in 1982 and 1987 from the University of Wyoming, Laramie. His doctoral dissertation involved the population dynamics and ecology of the White-tailed Prairie Dog in Wyoming. He then spent a year at the University of Wyoming as a post-doctoral research associate working on Black-footed Ferret reintroduction techniques. His involvement with Canada Geese followed as part of a research associate position with the New York Cooperative Fish and Wildlife Research Unit at Cornell University in Ithaca, New York.

In May 1989, Dr. Menkens returned to the University of Wyoming as Assistant Director of the UW-National Park Service Research Center and its field station in Grand Teton National Park. During his tenure, he was a high profile spokesman for the center immediately following the internationally monitored fires that swept the region and for the historic meeting held in the center's field station facility between U.S. Secretary of State James Baker and Soviet Foreign Minister Edward Shevardnadze.

Last May he resigned his assistant directorship to accept an appointment as a research biologist with the U.S. Fish and Wildlife Service's Alaska Fish and Wildlife Research Center in Anchorage. He worked with Brown Bears on the Arctic National Wildlife Refuge, then began an assignment to evaluate movement patterns of Polar Bears in relation to their habitat requirements. This is what he and fellow biologist, John Bevins, were doing at the time of their 11 October disappearance. Dr. Menkens was well-liked by his colleagues and collectively recognized as a solid research scientist. A more detailed memorial is found in the Wildlife Society Bulletin 19(2): 232–233.

RICHARD A. MALECKI

New York Cooperative Fish and Wildlife Research Unit, Department of Natural Resources, Ferow Hall, Cornell University, Ithaca, New Yortk 14853

13 December 1990

*See: Winter sightings of Canada Geese, *Branta canadensis*, banded in northern Quebec and James Bay. George E. Menkens, Jr., and Richard A. Malecki, Canadian Field-Naturalist 105(3): 350–353.

Letters to the Editor: Black-crowned Night Heron Banding Data

The excellent paper by Louis F. L'Arrivée and Hans Blokpoel (*Canadian Field-Naturalist* 104: 534–539) overlooked a published 1967 reference (C. S. Houston. Recoveries of Black-crowned Night Herons banded in Saskatchewan. *The Blue Jay* 25: 167–168) that used precise information no longer readily available from either banding office, concerning important early banding of Black-crowned Night Herons. This paper mapped 38 recoveries form 1131 night herons banded in Saskatchewan (859 banded by George Lang near Indian Head, 68 banded at Foam Lake by J. A. M. Patrick, 21 banded at Davidson by Fred Bard, and 183 banded by myself) and gave dates and localities for all bandings and recoveries.

The recovery rate was much higher for night herons banded in Saskatchewan alone between 1924 and 1955 (38/1131 of 3.4%) than for the 754 banded in the prairie provinces between 1955 and 1986 (7/754 or 0.9%). The larger numbers mapped the migration route of night herons from Saskatchewan somewhat more completely than the L'Arrivée-Blokpoel article.

C. STUART HOUSTON

863 University Drive, Saskatoon, Saskatchewan S7N 0J8

It is unfortunate that we, as well as at least five reviewers, missed reference to C. S. Houston's 1967 paper in *The Blue Jay*. In our paper, we stated that "Although recovery records date from 1942, neither the CWS Bird Banding Office nor the U. S. Fish and Wildlife Bird Banding Laboratory could provide us with banding records prior to 1955 due to a loss of data." As Dr. Houston mentions in his letter, his data "...were no longer available". It appears that Dr. Houston's paper fills in some of the gaps of this "missing" data and even includes "missing" recovery records.

Fortunately, our findings do not disagree with his, and his paper lends further support to M. A. Byrd's (1978. Pages 161–185 in *Wading Birds*. National Audubon Society Research Report 7) suggestion that Black-crowned Night Herons from the Prairie Provinces follow the Mississippi drainage to reach the Gulf of Mexico and the south Atlantic States during migration.

LOUIS L'ARRIVÉE[1] AND HANS BLOKPOEL[2]

[1]1022 Edmond Avenue, Ottawa, Ontario K1G 2R1
[2]Canadian Wildlife Service, Ontario Region, 49 Camelot Drive, Nepean, Ontario K1A 0H3

Erratum: The Canadian Field-Naturalist 104(3)

In the paper:

Barry, Ronald E., Jr., Alan A. Heft, and Thomas E. Baummer. 1989. Spatial relationships of syntopic White-footed Mice, *Peromyscus leucopus*, Deer Mice, *P. maniculatus*, and Red-backed Voles, *Clethrionomys gapperi*. Canadian Field-Naturalist 104(3): 387-393.

The figures at the bottom of page 389 are reversed. The correct positions are given below:

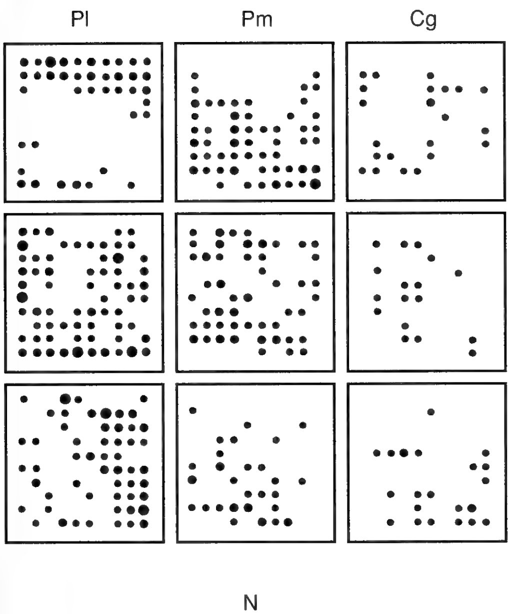


FIGURE 1. Distribution of captures of *Peromyscus leucopus (Pl), P. maniculatus (Pm),* and *Clethrionomys gapperi (Cg)* on the trapping grid during intervals 1, 2 and 3 (top to bottom) in the summer, 1985. N = north. • = 1-2 captures; • = 3-5 captures; • > 5 captures.

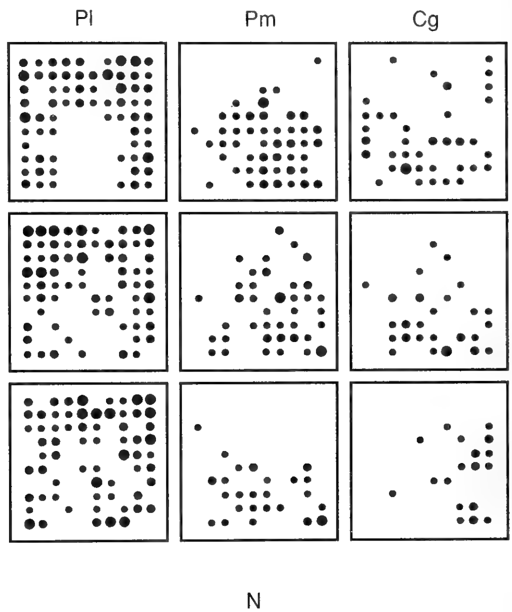


FIGURE 2. Distribution of captures of mice on the trapping grid during intervals 1, 2 and 3 (top to bottom) in the summer, 1986. See Figure 1 for legend.

RONALD E. BARRY, JR.

Department of Biology, Frostburg State University, Frostburg, Maryland 21532

Notice of the 1992 Annual Business Meeting of The Ottawa Field-Naturalists' Club

The 113th Annual Business Meeting of The Ottawa Field-Naturalists' Club will be held in the auditorium of the Victoria Memorial Museum Building, McLeod and Metcalfe streets, Ottawa on Tuesday 11 February 1992 at 2000 h.

CHRISTINE FRITH

Recording Secretary

Call for Nominations: The Ottawa Field-Naturalists' Club 1991 Awards

Nominations are requested from Ottawa Field-Naturalists' Club members for the following: Honorary Membership, Member of the Year, Service, Conservation, and the Ann Hanes Natural History Award. Descriptions of these awards appeared in *The Canadian Field-Naturalist* 96(3): 367 (1982). With the exception of nominations for Honorary Member, all nominees must be Club members in good standing.

ENID FRANKTON

Chair, Awards Committee, 2297 Fox Crescent, Ottawa, Ontario K2B 7R5

Call for Nominations: The Ottawa Field-Naturalists' Club 1992 Council

Candidates for Council may be nominated by any Ottawa Field Naturalists' Club member. Nominations require the signature of the nominator and a statement of willingness to serve in the position for which nominated by the nominee. Some relevant background information on the nominee should be also provided.

BILL GUMMER

Chairman, Nominating Committee, 2230 Lawn Avenue, Ottawa, Ontario K2B 7B2

Wolf Symposium '92

The Second North American Wolf Symposium, originally scheduled for 4-6 September 1991 (see *Canadian Field-Naturalist* 104(2): 308) was postponed and is now rescheduled for 25–27 August 1992. The symposium will be held on the University of Alberta campus (Edmonton, Alberta). Arrangements include a wolf-theme art gallery, a banquet, and a follow-up tour of the Rockies. There will also be a meeting of the IUCN wolf specialists one evening. Abstracts must be submitted to the Program Committee by 21 January 1992 and first draft by 1 April 1992. Early registration fees ($85 regular, student $15, including G.S.T.) are due by 1 June 1992. Late registration fees will be $115 regular and $30 student.

L. N. CARBYN

Wolf Symposium '92, University of Alberta, Canadian Circumpolar Institute, 215 Central Academic Building, Edmonton, Alberta T6G 2G1

Baillie Fund Grants Available for Bird Projects in 1992

Two types of grants are offered by The James L. Baillie Memorial Fund for Bird Research and Preservation to individuals and clubs who are planning bird projects:

(1) Project grants for support of research, conservation or educational projects on Canadian Birds; and

(2) Travel grants for participants in high priority fieldwork for breeding bird atlas projects. Travel grants are open to both residents and non-residents.

All projects must be conducted in Canada or on the wintering grounds or migration route of Canadian birds. Applications may be submitted by individuals or organizations. The Fund aims to support projects conducted by amateurs, projects using data collected by volunteers, and projects generally not eligible for other funding. As a result, graduate research is not the priority of the Baillie Fund. Grants are usually in the range of $200 to $2000 and the average grant is about $1000. Grants are made annually but multi-year support will be considered. Applications must be submitted on forms available from the Secretary.

The James L. Baillie Memorial Fund is funded primarily by the Long Point Bird Observatory and co-operating naturalists' clubs from proceeds from Canada's annual Baillie Birdathon. By taking part in the Birdathon, individuals and clubs support the Fund and raise money for their own projects. Information on participation in the Birdathon may be obtained from the Birdathon Coordinator at the Long Point Bird Observatory.

MARK STABB

Secretary, The James L. Baillie Memorial Fund for Bird Research and Preservation, c/o Long Point Bird Observatory, P.O. 160, Port Rowan, Ontario, N0E 1M0. Telephone (519) 586-3531.

Grants for Nongame Wildlife Research in Minnesota

The Minnesota Nongame Wildlife Program is soliciting proposals for projects to be conducted during the 1992 and/or 1993 field seasons (or longer) . Proposals should be for work contributing to the conservation and management of nongame wildlife (vertebrate or invertebrate or invertebrate) in Minnesota. High priority will be given to projects focusing on state endangered, threatened, or special concern species, native grassland species, wetland/aquatic species, and topics relevant to the management of state parks. Appropriate projects may include censuses/surveys, studies of life history/population dynamics/habitat requirements, assessments or identification of habitat quality/quality, design of long-term monitoring programs, development/evaluation of land use management techniques, and a wide variety of other topics. Awards average $3000 per year, but requests up to $10 000 per year will considered. The deadline for submitting proposals is 1 January 1992. Decisions will be announced no later than 1 March 1992. Funding comes from contributions to the Minnesota Nongame Wildlife Management Tax Checkoff and Minnesota State Parks merchandise sales. For program guidelines, proposal format, list of research ideas and other information please contact:

RICHARD J. BAKER

Nongame Wildlife Program, Minnesota Department of Natural Resources, Box 7, 500 Lafayette Road, St. Paul, Minnesota 55155-4007. Phone: (612) 297-3764.

Trumpeter Swan Project: Elk Island National Park, Alberta

Trumpeter Swans in Western Canada have made a dramatic comeback. Once occurring widely in North America from the Atlantic to the Pacific, only 127 were known to exist in 1933. Today, through international and local conservation efforts which have included winter feeding programs, the provision of special sanctuaries, and captive breeding and reintroduction, over 16 000 exist in the wild and about 2000 of these summer in Canada.

The Friends of Elk Island National Park Society is leading a multi-agency partnership to bring back the Trumpeter Swan to Elk Island National Park and the surrounding area. The goal of the project is to establish 10 breeding pairs in and around the Elk Island Park by 1996. Due to the return this year of three adults from their southern Idaho wintering area, the spring release of four yearlings from Camrose, and the recent capture and relocation of two male guide birds from Grand Prairie, there were nine swans summering in and around Elk Island National Park in 1991.

A one-year funding drive has resulted in approximately $10 000 from public and corporate donors. Environment Canada is contributing $25 500 over the next two to three years from its Environmental Partner's Fund. Robert Bateman and his publisher,Mill Pond Press, have agreed to contribute $25 000 per year for the next three years. Other project partners include Alberta Fish and Wildlife Division; World Wildlife Fund; Alberta Recreation, Parks and Wildlife Foundation; the city of Camrose; and the Camrose Veterinary Clinic.

IAN SHANDRUK

Environment Canada (403) 468-8907

Missouri Botanical Garden: Flora of North America Project

The Flora of North America Project is a collaborative, bi-national effort by more than 20 major botanical institutions to compile the first comprehensive descriptive catalogue of all plants growing wild in the United States and Canada. Until 1991 only the higher plants were to be included, but this year mosses and liverworts have been added to the workplan.

The Flora is the first reference work ever to bring together information on all North American plants. Over the next 10 years, the project will produce 13 volumes detailing approximately 20 000 plant species of all regions. In addition, the project is developing a computerized database that will be integrated in floristic databases for other regions of the world. In the area covered, north of Mexico, 38% of the native genera of vascular plants are found only in North America and an additional 18% are found only in the Western Hemisphere.

The FNA Organizational Center is housed in the Missouri Botanical Garden. The Project's Convening Editor is Dr. Nancy R. Morin, head of the Garden's Development of Botanical Information Management. Members of the project's 30-person Editorial Committee are at universities and museums throughout the United States and Canada. The project involves nearly 1 000 specialists and both contributors and reviewers are drawn from throughout the botanical community, North America and worldwide.

Volume I of the Flora will contain descriptions of ferns, fern allies, and gymnosperms as well as a series of introductory chapters covering the vegetational, climatic, and geological history of the North American continent. It is scheduled for publication in 1991.

Additional background information is available in "Botany Bids for the 'Big Science' League" *Science* 237: 967–968, 28 August 1987; and "The Flora of North America: Meeting a Century-Old Challenge" *Missouri Botanical Garden Bulletin* January/February 1988.

JANINE ADAMS

Public Relations Specialist, Missouri Botanical Garden, P. O. Box 299, St. Louis, Missouri 63166-0299

Workshop On Declines in Canadian Amphibian Populations: A Design for National Monitoring

There is a growing concern over reports of a world decline in amphibian populations that may be signaled by field observations indicating reduced or vanished populations from areas as far apart as California and Australia (*see* David B. Wake. 1991. Declining amphibian populations. *Science* 253: 860). Canadians have now joined the International Union for the Conservation of Nature (IUCN) effort to better monitor and evaluate the reality, extent, and the causes of perceived drops in amphibian numbers.

On the 5th and 6th of October 1991, Canadian herpetologists gathered to participated in a workshop at the Canada Centre for Inland Waters in Burlington, Ontario, organized and sponsored by Environment Canada and the Metropolitan Toronto Zoo.

A primary objective was to develop a national monitoring strategy for examining possible declines in Canadian amphibian populations. Christine Bishop (Environment Canada) and Bob Johnston (Metropolitan Toronto Zoo), presented the opening remarks at the workshop. They were followed by a world view of the problem by Jim Vial, Coordinator of the IUCN Declining Amphibian Populations Task Force. Subsequent presentations by Stan Orchard, Carolyn Seburn, Wayne Weller, Joel Bonin, Don McAlpine, John Gilhen, Wayne Roberts (given by Seburn), Bill Koonz, Michael Oldham, Michael Berrill, Christine Bishop and J. Murray Spiers (given by Bishop), Berrill (again), David Green, Roy McDiarmid, Francis Cook, Ronald Brooks, Bill Freedman, Jim Bogart, Richard Wassersug, Graham Crawshaw, Karen Clark, Christine Bishop and Bob Johnson covered distribution and population status known to date by province, examined methods and results for population monitoring projects, and outlined the impacts of diseases, effects of acid deposition and contaminants, and habitat loss. Bishop and Johnson concluded the first day with summaries and guidelines for the next day's discussions.

The second day was given over to creating the necessary working groups, defining their scope and objectives, and finding leaders. The following volunteers were chosen:

Representative for Canada, IUCN Task Force on Decline in Amphibian Populations — Bob Johnson, Metropolitan Toronto Zoo.

Task Force Coordinator for Canada — David Green, Redpath Museum, McGill University.

Regional Task Force Coordinators — Western Canada: Stan Orchard, Royal British Columbia Museum; Eastern Canada: Don McAlpine, New Brunswick Museum;

Provincial Task Force Coordinators — British Columbia: Stan Orchard; Alberta: Wayne Roberts, Museum of Zoology, University of Alberta; Manitoba: Bill Koonz, Manitoba Department of Natural Resources; Ontario: Mike Oldham, Ontario Ministry of Natural Resources, and Wayne Weller, Mississagua; Quebec: Joel Bonin, St. Lambert, and Roger Bider, MacDonald College of McGill University; New Brunswick: Don McAlpine; Nova Scotia: John Gilhen, Nova Scotia Museum.

In addition three subgroups were also formed to follow-up specific areas of data on Canadian amphibians:

Historical Population Trends: Martyn Obbard, Fred Schueler, Wayne Weller, and Michael Oldham.

Intensive Monitoring Studies: Mike Berrill, Jim Bogart, Ron Brooks, Francis Cook.

Extensive Monitoring Surveys: Bill Freedman.

Environmental Contaminants: Christine Bishop.

Diseases: Graham Crawshaw.

A second workshop or similar conference is being planned and will be held in the fall of 1992, hosted by D. M. Green at the Redpath Museum at McGill University, Montreal, Quebec. A more extensive account of the first workshop, by Hinrich Kaiser, appears in the Canadian Association of Herpetologists Bulletin 5(2): 1–4 (October 1991).

The Proceedings of the first workshop, containing abstracts of presentations, is scheduled for printing and distribution as a Canadian Wildlife Service Publication, early in 1992. Copies may be obtained, when available, from Christine Bishop, Canadian Wildlife Service — Ontario Region, Canada Centre for Inland Waters, 867 Lakeshore Road, P.O. Box 5050, Burlington, Ontario L7R 4A6.

The Canadian Association of Herpetologists Bulletin has been chosen as the official news medium on the progress of working group. Dr. Green is its Editor. The Bulletin may be obtained by joining the Canadian Association of Herpetologists (annual membership $10). Application for membership and payment of dues should be forwarded to Dr. Patrick T. Gregory, Treasurer, CAH, Department of Biology, University of Victoria, Victoria, British Columbia V8W 2Y2.

FRANCIS R. COOK

Canadian Museum of Nature, P. O. Box 3443, Station D, Ottawa, Ontario K1P 6P4

Components of the Economic Value of Wildlife: An Alberta Case Study

W. L. ADAMOWICZ[1], J. ASAFU-ADJAYE[1], P. C. BOXALL[2], and W. E. PHILLIPS[1]

[1]Department of Rural Economy, University of Alberta, Edmonton, Alberta T6G 2H1
[2]Fish and Wildlife Division, Alberta Forestry Lands and Wildlife, Edmonton, Alberta

Adamowicz, W. L., J. Asafu-Adjaye, P. C. Boxall, and W. E. Phillips. 1991. Components of the economic value of wildlife: An Alberta case study. Canadian Field-Naturalist 105(3): 423–429.

Wildlife resources and the services they provide are not typically traded in markets. In spite of a high regard for wildlife resources by individuals, the value of wildlife is often assigned a low or zero price in economic analyses that include trade offs with industrial developments. A partial reason for this anomaly is the lack of market prices for the various kinds of uses or services derived directly from wildlife, including the value of wildlife preservation. In this paper methods of determining values for wildlife resources are discussed. The role of these values in benefits cost analysis is addressed. An empirical analysis of components of wildlife value from an Alberta case study is presented. The analysis includes both use and non-use values. The results suggest that non-use values, or preservation values, represent a large component of the value of wildlife.

Key Words: Wildlife values, nonmarket value, contingent valuation, economic analysis, benefit-cost analysis.

Within the last decade, concern for the environment has risen to the top of the agenda of national and international issues. In Canada, concern for wildlife is high among the various environmental issues (Federal-Provincial Wildlife Conference 1983). In Alberta, 87% of the population over the age of 15 state that maintaining abundant wildlife populations is important (Filion et al. 1989). In spite of this high regard for wildlife resources, the value of wildlife is often assigned a low or zero price in economic analyses that include trade offs with industrial developments. A partial reason for this anomaly is the lack of market prices for the various kinds of uses or services derived directly from wildlife. There are non-use or preservation values associated with wildlife that are nonmarket in character also. Consequently, decisions have been made in the past in which the contribution of wildlife has been under-represented. This has sometimes resulted in decisions which have posed adverse implications for the sustainability of wildlife populations.

The purpose of this paper is to outline the components of wildlife values, an evaluation framework, methods of valuation, and recent empirical results. The empirical focus is on use values derived from consumptive use (e.g., hunting), non-consumptive use (e.g., birdwatching) and on non-use (e.g., preservation) associated with wildlife in Alberta. There are other potential categories of use that have value. At the present time empirical information on these is lacking.

Society is capable of providing an increasing volume and array of human-made goods and services, but is largely incapable of creating natural environments including wildlife and wildlife habitat. The reduction in natural environments results in increased values (through increased scarcity) for those natural amenities, including wildlife. At the same time, however, demand levels for wildlife and other natural environmental components and systems have increased. If we as a society are to make informed choices about how much of a natural environment, including wildlife, we wish to maintain or preserve, and how much we wish to irreversibly alter, some effort must be made to supplement market value information with nonmarket value information.

Wildlife Values

In order to assess the economic and social importance of wildlife, an understanding of the components of wildlife value is essential. Note that we are generally interested in the value of wildlife-related services rather that the value of an individual animal or species. A potential framework for value is identified in Figure 1. There are two broad value categories, use and non-use. Use values are more readily understood and have been the primary focus for economic evaluation during the past three decades.

Use values can be divided into direct and indirect use values. Direct use values are further subdivided into consumptive and non-consumptive use values. Consumptive-use values are related to activities such as recreational hunting and commercial harvest including ranching operations. Consumptive use has an impact on wildlife populations; it removes individual animals from their natural environments. Non-consumptive use values, on the other hand, do not affect wildlife populations directly. They are associated with such activities as wildlife viewing and study. The importance of nonconsumptive use of wildlife is only now being

recognized on a par with consumptive uses (e.g., Butler 1983). Indirect use values arise through the vicarious enjoyment of wildlife through published material, media documentaries and the like. There are no empirical data in Alberta indicating the importance of these values. Consequently, indirect use values are not part of the focus of this paper.

Non-use values are based on either potential future consumption or current satisfaction from the knowledge that wildlife resources exist. They can be broken into three categories, existence, bequest and option values. Existence value is a value assigned to the knowledge that a resource such as a wildlife species exists, regardless of whether or not the individual uses or consumes the resource today or will wish to do so in the future. Individual donations to wildlife funds, societies, and preservation groups are evidence of existence values.

Bequest value, on the other hand, is based on the potential use of the resource by the individual's descendants. In other words, people are willing to pay to preserve a resource or resource system for their children or grandchildren. Finally, option value is a value derived from the fact that future supply and/or demand for the resource are uncertain. It will vary depending on the values for the resource or activity and on the risk preferences of individuals. While a part of economic value, option value may be negative, depending on risk-taking behavior and preferences over wildlife services on the part of each individual.

The components of wildlife value identified here have been subjected to considerable measurement efforts by economists. Direct-use values have been most commonly measured during the last three decades, and rapid development of appropriate measurement techniques has taken place during this time. Efforts to measure indirect and non-use values are very recent and development of appropriate techniques is still underway. This topic is addressed below in the section on methods.

Benefit Cost and Impact Analysis

Unlike market goods and services, the demand signals from consumers (recreationists) for wildlife services as well as non-use components are not readily conveyed to resource-use managers and other decision makers due to the absence of defined markets and prices. As indicated earlier, outdoor recreation and other environmental interests must find other means of registering nonmarket values through various organizations including wilderness and parks associations, fish and game associations, and preservation groups. These groups play an important role as a counterbalance to competing private commercial interests that may displace or alter natural environments. Generally, the allocation of resources to industry are arrived at through public decision making without the knowledge of measured economic values associated with noncommercial resource uses. Wildlife and other environmental interests cannot afford to ignore such explicit values. Furthermore, public sector agencies must]he concept of *economic efficiency* is at the center of this analysis. It has to do with whether or not the benefits are greater than costs and if so, by how much. If, for example, a decision is made to displace or alter a natural area in favor of resource commodity extraction, what does society gain and what does society lose? Are the gains sufficient to more than offset the losses; that is, are the net gains or net benefits positive? Generally, the greater the net benefits the more economically efficient the resource allocation decision. Choosing the resource use pattern that renders the greatest net benefit to society may be an appropriate criterion in resource use decisions. However, resource use values, including wildlife values, must be known if we are to quantify benefits and costs. Part of the cost of choosing any resource use pattern is the net benefits foregone from displaced uses. Part of the social costs of economic growth have been the loss of social benefits associated with displaced natural areas. As indicated above, these costs have not been fully recognized historically, in part because estimates of (nonmarket) value have been lacking. Efforts to increase our social well-being can be facilitated by increased attention to issues of economic efficiency in resource use tradeoffs involving nonmarket values. Determination of these values, wherever possible, is essential.

Associated with the concept of efficiency is the concept of *equity*, or fairness, in which questions about the incidence of benefits and costs among specific individuals or groups in society are addressed. Who gains and who loses from changes in the use of our environment? For example, a reduction in amenity services including wildlife, from resource extraction or waste assimilation results in losses to naturalists, outdoor recreationists, and others who value these resources. The gains elsewhere in society from the alternative use may more than offset the losses and therefore justify the environmental alteration as an efficient allocation of resources. But is such a loss tolerable? The collective values of society may lead to the answer "no" once a certain point is reached in the reduction of natural environments. Thus the most acceptable resource use pattern, on efficiency grounds, may be less than desirable on equity grounds.

Equity judgments are societal decisions revealed largely through the political process and made explicit through formation and implementation of public policy. Economic efficiency considerations can be an important part of that process but will be constrained by equity or fairness considerations. However, environmental resource-use considerations on equity grounds can be served by the ex-

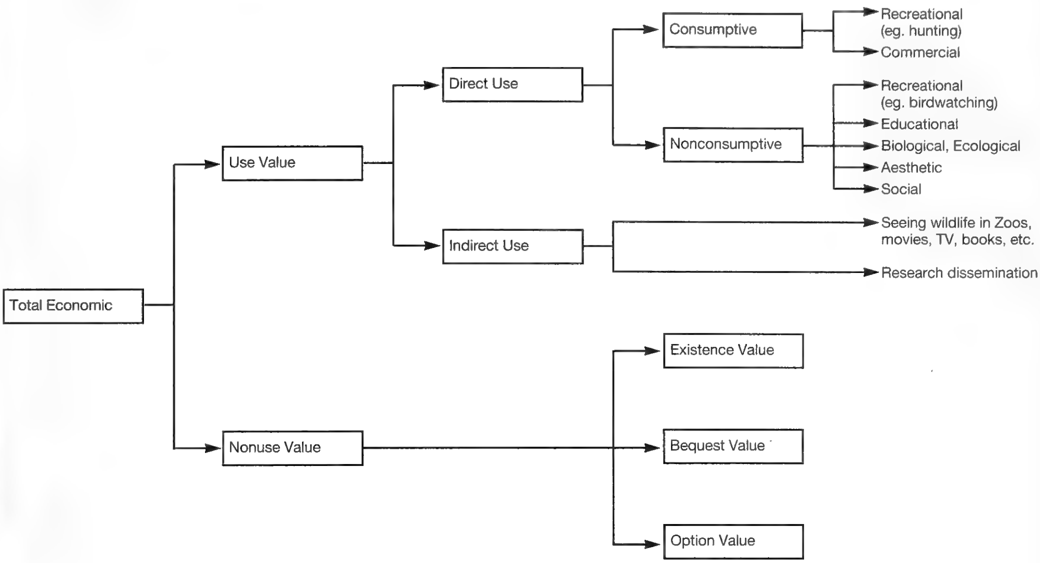


FIGURE 1. Components of the total value of wildlife.

amination of nonmarket values and their distribution throughout society. Benefit-cost analysis, therefore, is useful not only in arriving at net benefits (benefits less costs) but in tracking who gains and who loses.

Any economic activity has associated with it local or regional impact. Wildlife-related expenditures are at the center of impact analysis involving wildlife considerations. Such analysis focuses on inter-sectoral or inter-regional transfers and is distinct from benefit cost analysis which focuses on economic efficiency and equity through emphasis on wildlife values and management/enforcement costs. In essence, the wildlife resources generate both economic values and expenditures. Unfortunately, many individuals consider expenditures to represent value. This is not the case. Individuals who live adjacent to prime wildlife habitat will spend little in travel and lodging to enjoy the resource. Their personal values of the wildlife resource, however, may be many times greater than the value held by an individual who incurs great expense in travelling to enjoy the resource. While expenditures are not appropriate as a measure of value, they are important for determining the regional economic impact of activities involving wildlife resources.

Regional economic impact is a measure of the generation of economic activity in a region which is stimulated by the injection of external funds. Several businesses within a small town near a wilderness area, for example, may benefit from the money brought in by wildlife oriented tourists. The income generated in these businesses is spread throughout the community. It must be made clear, however, that these economic impacts are important on a regional scale, and are likely not useful on a provincial or national level. If an area is closed to hunting, individuals will still spend their money, either by hunting in other places or by spending it in some other activity (e.g., professional sporting events).

The economic value for the resource, however, always remains with the resource and while expenditures are not appropriate measures of value per se, they often provide a mechanism by which value can be inferred and subsequently used in benefit cost analysis. This approach to valuation is discussed below in the section on methods.

Methods

Valuation Methods

In attempting to derive values of nonmarket goods for use in benefit cost analysis economists have developed two different approaches. The first approach, the indirect or inferential approach, uses actual market observations to infer a value for the nonmarket good. The travel cost model, originally conceived by Hotelling (1947) and recreated by Clawson (1959), is based on an examination of the quantity of trips to a recreation site as costs to reach the site increase. Using cross-sectional data, estimates of how recreationists respond to price can be developed in the same manner as a demand curve for any traditionally priced good. The "price" of the recreation trip is the travel (and associated variable) cost. The demand curve for trips to the site can then be used to determine the "willingness to pay" for trips to the site. The latter is a measure of the economic value of the site.

A number of assumptions are made in the inferential approach. Details on these assumptions and their implications can be found in Fletcher et al. (1990). The inferential approach has been used to derive values for sites, for quality changes in recreation sites and for various management changes. However, valuation in this case requires that market data on recreational use be available. Therefore, this approach cannot be used to value goods or services which do not involve some market expenditure on travel or other goods. For example, the inferential approach cannot be used to estimate the existence or preservation value of wildlife.

A second approach, the direct or contingent valuation approach, attempts to place a value on goods contingent on there being a market price for the goods or service. This technique rests on two assumptions. First, the respondent understands the goods or service being described and can place a value on it. Second, the individual does not misrepresent this value. These assumptions can fail for a number of reasons. For example, if the individual is not familiar with the goods or cannot imagine paying for the goods in the manner described then the results are of limited value. Indeed, in such occasions there may be a tendency for non-response. Also, if an individual sees the valuation experiment as an opportunity to behave strategically, then the valuation will be biased. Considerable research on these assumptions suggests that careful design in the survey procedure can limit the difficulties due to misunderstanding the goods or service, and that strategic behavior tends to be quite infrequent (*see* Mitchell and Carson 1989).

A particular aspect of contingent valuation research hinges on the fact that individuals do not actually pay the amount they state as their willingness to pay. This characteristic has lead to a number of studies of individual behavior in response to hypothetical questions. The landmark study in this literature is Bishop and Heberlein (1979). These authors compared hypothetical valuation question results with actual cash outlays for goose hunting permits. There was no significant difference between the two values. The findings do suggest that a properly structured contingent valuation study can reveal a value which is not different from the amount that people would actually provide in a market. Naturally, as one deviates from the assumptions required for the contingent valuation method, the chances of hypothetical results actually representing market outlays decreases.

The purpose of this study is to determine the value that individuals place on various aspects of wildlife. In particular, the value individuals place on wildlife preservation will be examined using a contingent valuation question. Use values of wildlife will be obtained from a similar contingent valuation procedure used in the National Survey of the Value of Wildlife to Canadians (Filion et al. 1989).

Preservation Value: The Household Survey

Preservation values, as defined above, are values that individuals place on the resource independent of use values. In an attempt to derive such values, a random sample of Alberta households were asked how much they would be willing to pay, into a trust fund, for the preservation of wildlife. The details of this mail survey are presented below.

A random sample of 2400 Alberta households was drawn from telephone directories of Alberta Government Telephones and Edmonton Telephones. Telephone directories provide a mechanism for sampling most households in the province as a large percentage of households are listed. The telephone directories were arranged in random order. Areas with multiple listings were removed from the group to prevent duplication. The sample was chosen by every 300th entry in the telephone directory after a random start.

The survey instrument was pre-tested and received considerable input from Alberta Fish and Wildlife Division staff. Budgetary considerations constrained the number of mailings to one. The response rate, adjusted for undelivered questionnaires was approximately 30%.

A number of potential biases arise in the use of such a mail survey. First, non-response bias is a possible problem. While the response rate to this survey was not high, such a response rate is not unexpected from a single mail wave survey. Non-response bias may be evident in such a survey in the hypothetical valuation questions as individuals who reject the notion of valuation refuse to respond to the survey (Mitchell and Carson 1989). However, the distribution of dollar amounts received in the valuation questions included zero, positive values and refusals in response to the question. While this does not rule out the possibility of non-response bias, it does provide some evidence that response bias has not entirely limited the variability in response to the valuation questions.

Due to the limited budget no second mailings or non-response follow up surveys were possible. However, in other surveys of a similar nature and with similar response rates these authors have found little evidence of non-response bias. A survey of Alberta resident hunters which was carried out at approximately the same time as this household survey was tested for non-response bias using the responses to the second mailing of the surveys as non-respondents to the first mailing. The results revealed no significant differences between the two mailings for a variety of variables. This test is also not a definitive test of response bias but these results may be considered a minimum bound test of response bias.

A second potential response issue is the question of the valuation vehicle. It is possible that response to the valuation question will differ depending on the payment vehicle, ie. taxes or donations. In an attempt to address this issue, half of the sample was presented with a valuation question worded as follows:

The population levels of several species of wildlife in the province are declining due to deteriorating habitat quality and increasing contact with humans. This situation has developed mainly as a result of the increasing use of natural wildlife habitat for various purposes such as timber harvesting, mining, farming, etc.

Suppose a public trust fund was set up to pay for a 5 year wildlife management program to preserve wildlife in the province. This program would include restricting access to selected areas and improving wildlife habitat.

Regardless of whether or not you plan to hunt, watch, feed, photograph or study wildlife, what is the maximum amount of money you would be willing to donate annually to the fund for the preservation of wildlife, if the amount you indicate would be represented by an increase in your income tax?

The question was followed by a "payment card" which contained a sequence of values from $0 to $900 and a line which asked "If higher or other dollar value, please specify."

The other half of the sample was asked the same question with the following words removed:

"if the amount you indicate would be represented by an increase in your income tax."

The first payment vehicle represents a tax payment while the second represents a donation. There was no significant difference in amounts between the tax and donation options, therefore, there is no evidence of vehicle bias. Accordingly, the two samples were pooled before reporting the results.

Use Values: The National Survey

Consumptive and nonconsumptive use values of wildlife were obtained from the National Survey on the Value of Wildlife to Canadians (Filion et al. 1989, 1990). This survey was administered by Statistics Canada as a supplement to its Labour Force survey. Over 10 000 Albertans were contacted by interviewers. The response rate was over 70 percent. The values of hunting and non-consumptive activities were derived using contingent valuation questions. These questions were framed as:

"How much more would you have spent before deciding not to take these outings or trips in 1987?"

The question was followed by a set of dollar categories. For details see Yiptong and Duwors (1990).

Results and Discussion

Using the contingent valuation procedure described above, the preservation value of wildlife was estimated to be $80.92 per household in 1987 (Table 1). As mentioned above, it is difficult to define the specific non-use service(s) that provide benefit to an individual. However, these services include the mere existence of the wildlife resource, the opportunity to pass on use and non-use benefits to future generations, and likely some aspect ensuring the opportunity to engage in future wildlife-related activities. The aggregate value of non-use benefits is estimated to be about $67.7 million dollars per annum.

Table 1 also presents estimates of the economic values of consumptive and non-consumptive use benefits of wildlife in Alberta during 1987. Albertan hunters derived annual benefits of $119.10 to $211.10 per person for hunting various wildlife groups during 1987. An average value for all hunting activities was calculated by multiplying the mean value for each wildlife group by the estimated number of participants, and dividing by the total number of participants. This weighted average value was approximately $165.9 per hunter. These values estimate the monetary magnitude of the benefits Albertans gain from hunting activities. Thus, the provincial wildlife resource provides hunting services worth in aggregate over $53 million dollars per annum.

Another category of use benefits involves non-consumptive uses. These include activities such as bird watching, scientific study, photography, and the simple observation of wildlife in their natural environment. During 1987, Albertans received benefits valued at approximately $162.90 per participant in non-consumptive activities (Table 1). Multiplying this mean by the number of participants results in a total value for non-consumptive use of about $64.5 million. This figure represents the value of the non-consumptive recreational services that Alberta's wildlife provides its citizens.

Considering that the wildlife resource of Alberta is a renewable asset, its value can be approximated by summing the components measured above. This summation results in a total **annual** value of $185.2 million (Table 1). However, as with most assets which generate revenue or benefits on a periodic basis, we have simply measured the annual return from the services the wildlife resource provides Albertans. To translate this annual benefit into the present value of the asset, the annual returns from wildlife in all future time periods must be considered. This is done by discounting the benefits accruing in all but the initial time period. Since the province's wildlife resources are publicly owned, and are presumably managed to provide benefits in perpetuity, discounting involves dividing the annual benefit by the social discount rate (Howe

TABLE 1. Estimate of the economic values of wildlife in Alberta

	$ Values per person per year		Aggregate $ Values (millions)	
	Mean	No. of participants	Annual (1987)	In perpetuity[1]
Preservation Benefits[2]	80.9	836 125	67.7	1354
Hunting[3]				
Waterfowl	171.8	59 730	10.3	206
Other birds	130.0	84 827	11.0	220
Small mammals	119.1	56 738	6.8	136
Large mammals	211.1	118 207	24.9	498
All hunting	165.9		53.0	1060
Non-Consumptive Use[3]	163.0	395 873	64.5	1290
Total Economic Value			185.2	3704

[1]These aggregate values are calculated using an estimated social discount rate of 5%, and are reported in 1987 dollars.
[2]These values were derived from a 1987 Household Survey detailed earlier in the paper.
[3]Values used here were taken from unpublished data from the 1987 *National Survey on the Importance of Wildlife to Canadians*, and from Filion et al. (1990).

1979). The appropriate choice of the discount rate is thus crucial to the estimation of the net present value.

Market or prime interest rates are reflective of three main components: i) the social discount rate; ii) rate of inflation; and iii) lender's risk (Randall 1981). Although numerous studies have attempted to provide insight into the magnitude of the social discount rate none have been definitive. What is clear is that it is less than the market rate and generally ranges from about 3 to 8 percent. Using a rate of 5 percent, generally in the middle of this range, the present value of the services we have measured of the wildlife resource in Alberta is about $3.7 billion (Table 1).

A number of uses or services of the wildlife resource in the province have not been measured in this study; the most notable being commercial uses. Commercial uses include the trapping, guiding and outfitting industries, wild game meat packing and processing services, and game ranching. It is interesting to note that these values are measured by market prices and are the ones most commonly included in analyses of the impact of natural resource industrial expansion on wildlife resources. Although specific values are not readily available for 1987, these commercial uses involve few participants and do not generate significant economic activity relative to the values we have reported above (e.g., Boxall 1986). Other values not included in this study are the value of wildlife services in Alberta to non-residents. Thus the total economic value we report here is a conservative estimate.

Within the total economic value of wildlife it is apparent that non-use values may comprise a significant portion of the total. In our study, preservation benefits represented over a third of the total annual value (Table 1). This is the first published attempt in Canada at measuring these values, and should prompt further research into refining the measurement and use of these values in wildlife management activities. Few studies of the economic value of wildlife-related activities take into account non-use values (e.g., Filion et al. 1990); it is apparent that their omission may represent a significant undervaluation of wildlife resources.

In the United States, economists have attempted to measure non-use values of wildlife resources using contingent valuation techniques, but have focused on individual species. For example, Brookshire et al. (1983) estimated existence values for Grizzly Bears and Bighorn Sheep. Their study utilized a 5-year program scenario similar to ours and revealed mean existence values per citizen in Wyoming of $24.00 and $7.40 for the two species respectively. Bowker and Stoll (1988) found that willingness to pay into a trust fund to ensure the continued existence of the Whooping Crane ranged from $21 to $70 per individual. Boyle and Bishop (1985) measured the total economic value of Bald Eagles in Wisconsin. They found that citizens, depending on their involvement in wildlife-related activities, would donate sums ranging from $18.02 to $75.31 to an endangered species program that would preserve eagles.

Our Alberta estimates of non-use values (Table 1) are somewhat higher than the non-use values described above. However, considering that our estimates involve the provincial wildlife resource and not an individual species, this may not be unexpected.

The nonmarket values we describe in this paper are measurable, and are appropriate for use in investigating the economic efficiency of resource allocations through benefit cost analysis. However, nonmarket values can be used in other ways. For

example, recent research efforts are using nonmarket values in measuring the effects of changes in environmental quality on societal well-being. With respect to wildlife in Alberta, measuring and priorizing alternative wildlife management programs based upon their effect on the benefits received by citizens would be a novel approach. Estimation of nonmarket values enable managers to quantitatively measure the effect of changes in environmental or recreation quality on wildlife and hence on economic benefits or welfare. For example, Coyne and Adamowicz (1990) were able to measure changes in benefits associated with: the closure of any of 10 Bighorn Sheep hunting sites in Alberta, an increase in the population of sheep at these sites, and changes in the congestion of hunters. Findings such as these for all uses of wildlife will assist wildlife managers in planning programs that can best meet the interests of both the wildlife recreationist and those that do not "use" wildlife but still care for it. Provincial government wildlife management agencies purport to act in the best interests of society, and should consider nonmarket values as an important information base for decision making.

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Received 19 April 1990
Accepted 14 December 1990

Minutes of the 112th Annual Business Meeting of The Ottawa Field-Naturalists' Club : 8 January 1991

Place and Time:	Auditorium, Victoria Memorial Museum Building, Metcalfe and McLeod Streets, Ottawa, 20:15 hrs
Chairperson:	Jeff Harrison, President
Attendance:	Thirty-one people attended the meeting

1. Minutes of the Previous Meeting

Deirdre Furlong, Acting Recording Secretary, read the minutes of the 111th Annual Business Meeting. It was moved by Ken Strang (2nd Barbara Campbell) that the minutes be approved.

(*Motion Carried*)

2. Business Arising from the Minutes

a) The matter of finding permanent office space for the Club is still outstanding. In addition, the Club has had to make alternative arrangements for its Council meetings. Roy John mentioned that thanks to the efforts of Libby Fox, Council has been accorded the use of The Friends of the Farm Office at the Arboretum of the Central Experimental Farm, as of February, 1991. He cited further the diligence of Jeff Harrison in securing a verbal commitment from the Canadian Museum of Nature for the continued use of its Auditorium, free of charge, for the Club's Monthly Meetings. The Museum will also continue to provide room in its basement for Macoun Field Club activities.

b) An article thanking Monty Brigham for his years of service as Club Auditor appeared in *Trail & Landscape*, Volume 24, Number 2.

c) A report of the February, 1990 Scott House Workshop on future directions for the Club has not yet been published in *Trail & Landscape*. This will be done once all Committees have responded to the recommendations which resulted from the workshop.

3. Financial Report

a) Frank Pope (Chair, Finance Committee) reported on behalf of Mick Schromeda, who resigned as Treasurer after accepting employment in Nova Scotia. The preparation of the financial statements is the Treasurer's responsibility, and the Club wishes to thank the Auditor, Janet Gehr, for assuming and completing this task.

b) The Financial Statements consist of:

i) *Balance Sheet*: The assets are balanced against the sum total of the liabilities, funds, life memberships and members' equity. Members' equity is the Club's accumulated surplus of funds as of September 30, 1990. It has grown to $131,657.

ii) *Statement of Members' Equity*: Excess incomes attributable to OFNC and CF-N operations were virtually equal. Donations and grants ($3,066) were down substantially, while the income from the sale of records and tapes ($1,614) was slightly higher than the previous year.

iii) *Statement of Operations – OFNC*: The excess of income over expenses was $6,024, compared to last year's figure of $366. Interest income was up approximately $1,000. Excursions and Lectures had a large surplus of $2,016. Special publications had a surplus of $656 as opposed to a deficit of $1,304, the previous year. Depreciation was approximately $1,000 less than in 1989.

Colin Gaskell asked why the affiliation fees were down by $200. The Club's FON membership fee is still outstanding.

iv) *Statement of Operations – CFN*: The excess income over expenses was down approximately $3,000, compared to last year, although income was up slightly. Publishing expenses ($60,264) increased from last year ($53,920). The editing and the office supplies expenses decreased substantially. The purchase of a new computer accounted for the figure of $3,907 under equipment expenses.

A question was asked about the decrease in income from subscriptions. Bill Cody answered that funding cutbacks within institutions and late billing due to publication delays were contributing factors. As well, for some unknown reason, a number of first billings to the USA were lost in the mail.

Cody also commented that the income from the publication of extra pages ($34,834) had increased from $20,801, and was due to payments from the Canadian Wildlife Service and COSEWIC for specific articles.

It was moved by Frank Pope (2nd Don Davidson) that the Financial Report be accepted.

(*Motion Carried*)

4. Nomination of Auditor

a) Janet Gehr audited the OFNC's books for the 1989/90 fiscal year and found everything in order. She has agreed to continue in this position.

b) Frank Pope moved the appointment of Janet Gehr as Auditor of the accounts of The Ottawa

Field-Naturalists' Club for the 1990/91 fiscal year (2nd Don Davidson).

(*Motion Carried*)

5. Report of Council

The reports were read and discussed as follows:

a) *Awards Committee:* The report was read by Roy John. There were no questions or comments.

b) *Birds Committee:* The report was read by Jeff Harrison. Colin Gaskell asked about the location of the Bird Status Line records. They are presently being kept in Larry Neilly's home. Due to storage problems at the Public Archives, the Club is not sending any documents to be housed there at present.

c) *Computer Management Committee:* The report was read by Deirdre Furlong. There were no questions or comments.

d) *Conservation Committee:* The report was read by Roy John. There were no questions or comments.

e) *Education and Publicity Committee:* The report was read by Jeff Harrison. There were no questions or comments.

f) *Excursions and Lectures Committee:* The report was read by Roy John. There were no questions or comments.

g) *Executive Committee:* The report was read by Deirdre Furlong. There were no questions or comments.

h) *Finance Committee:* The report was read by Jeff Harrison. There were no questions or comments.

i) *Macoun Field Club Committee:* The report was read by Deirdre Furlong. There were no questions or comments.

j) *Membership Committee:* The report was read by Roy John. Bill Gummer commented that the table should show a total number of 25 Honorary Members. The table has been corrected accordingly.

Steve Blight expressed surprise at the decrease in membership considering the increase in public awareness in the environment, and asked whether the Club was planning a membership drive. Jeff Harrison agreed with this observation and added that there have also been a number of new groups formed recently (e.g. ECOVISION) to deal specifically with environmental concerns. The Membership Committee will be sending out an additional third renewal notice to discourage lapses in membership. Ken Strang commented that the fluctuation in membership has been consistent over the past ten years. As a past Membership Committee Chairperson, Barbara Campbell agreed with Strang. Bill Gummer added that Club membership has risen appreciably from ten years ago. Roy John observed that if the Club wishes to augment its membership, it must be prepared to accommodate this increase. For example, the Excursions and Lectures Committee gives special consideration to the number of participants when planning events.

k) *Publications Committee:* The report was read by Jeff Harrison. There were no questions or comments.

It was moved by Jeff Harrison (2nd Frank Pope) to accept the Report of Council.

(*Motion Carried*)

6. Report of Nomination Committee

a) Bill Gummer reported the following members nominated for the 1991 Council and the slate of officers:

President: Roy John (Executive**)
(Excursions and Lectures**)
Vice-Presidents: (to be announced)
Treasurer: Gillian Marston*
Recording Secretary: Christine Firth*
Corresponding Secretary: Eileen Evans

Other Council members:

Ronald Bedford (Publications**)
Colin Gaskell
Barry Bendell (Macoun Field Club**)
Bill Gummer
Jeff Harrison
Steve Blight
Stewart MacDonald*
Fenja Brodo*
Linda Maltby*
Martha Camfield* (Conservation**)
Bill Cody
Frank Pope (Finance**)
Francis Cook
Doreen Watler
Don Cuddy (Membership**)
Elizabeth Fox
Ken Young*
Enid Frankton (Awards**)

Notes:
(*) Indicate new members of Council.
(**) Committies. Committee Chairpersons are those with a committee name shown in parentheses.

Other Committee Chairperson: Suzanne Blain (Computer Management).

The Birds Committee and the Education and Publicity Committee are presently without chairpersons.

One of the new Council's first jobs will be to choose its two vice-presidents, since no one has come forward at this time.

b) The following Council members resigned during 1990:

Don Davidson
Elizabeth Morton (Editor, *Trail & Landscape*)
Deirdre Furlong (Education & Publicity)
Mick Scromeda (Auditor)
Paul Hamilton
Ken Strang

It was moved by Gummer (2nd Barb Campbell) that the slate of officers nominated for the 1991 Council be approved.

(*Motion Carried*)

Bill Gummer welcomed all new Council members.

7. New Business

a) Jeff Harrison spoke of his renewed faith in volunteerism during his two years as Club President. He outlined several important Club accomplishments achieved in 1990:

i) The Scott House Workshop has provided a starting point for the Club to move in new directions based on the input from concerned members and Club Committees.

ii) Green Line, edited by Michael Murphy, has become a regular supplement to *Trail & Landscape*, dealing with local environmental issues.

iii) After several years of planning, a site for the Wildlife Garden has been found and a Wildlife Garden Committee has been organized. This project will be of particular value in educating the public about nature in an urban environment.

iv) The cost of publishing Dan Brunton's *Nature and Natural Areas in the Ottawa District* was recovered this year by The Citizen. This means that any future profits will go to conservation activities within the Club.

While addressing the topic of the Club's future plans, Harrison expressed the hope that the Scott House initiative be continued. Perhaps the Club should examine its directions every five years, and consider modifications within the organization. He also mentioned that the Club will be hosting the FON's Annual Conference in 1993.

Harrison expressed his thanks to Council and Committee members for their hard work during his term as President.

b) Bill Gummer thanked Harrison on behalf of Club members for his time and efforts during the past two years.

c) Frank Pope told members that the Club would not be charging GST. In 1991, GST will cost the Club an extra amount of \$1,500, however, the Club will be able to claim 50% of any GST paid.

d) Colin Gaskell announced that due to GST now being charged on bus rentals, the cost of the Pelee trip will increase by approximately \$20 per person. The exact amount will be finalized at the next Excursions and Lectures Committee meeting.

e) Copies of *Legacy: The Natural History of Ontario* are for sale at a cost of \$34.50 through the Club. The book normally retails for \$75.

8. Adjournment

At 21:50, Jeff Harrison (2nd Bill Gummer) moved that the meeting be adjourned. Members were invited to meet downstairs for refreshments after the meeting.

DEIRDRE FURLONG
Acting Recording Secretary

Auditors' Report

To the Members of
The Ottawa Field-Naturalists' Club:

I have examined the balance sheet of the Ottawa Field Naturalists' Club as at September 30, 1990 and the statement of operations, for the year then ended. My examination was made in accordance with generally accepted auditing standards, and accordingly included such tests and other procedures as I considered necessary in the circumstances.

In my opinion, these financial statements present fairly the financial position of the Club as at September 30, 1990 and the results of its operations for the year then ended in accordance with generally accepted accounting principles, applied on a basis consistent with that of the preceding year, except as noted in Note 2 to the financial statements.

CHARTERED ACCOUNTANT
January 8, 1991

The Ottawa Field-Naturalists' Club Notes to the Financial Statements: September 30, 1990

1. Authority and Activities

The Ottawa Field-Naturalists' Club is a non-profit organization incorporated under the laws of the Province of Ontario (1884). The Ottawa Field Naturalists' Club promotes the appreciation, preservation and conservation of Canada's natural heritage; encourages investigation and publishes the results of research in all fields of natural history and diffuses information on these fields as widely as possible. It also supports and cooperates with organizations engaged in preserving, maintaining or restoring environments of high quality for living things. Membership is open to any person or family, upon application and payment of dues. Payment of the Annual Dues as set out in the By-laws will be a necessary condition for the continuance of Membership.

2. Significant Accounting Policies

Memberships, subscriptions and donations are recorded as received. All other revenues and expenditures except for inventory are accounted for on the accrual basis. Memberships are allocated to the Canadian Field-Naturalist publication on a pre-determined percentage.

Supplies, records, tapes and other items held for resale are expensed when purchased.

Fixed assets are recorded at cost and are depreciated on a straight-line basis, for assets acquired prior to 1990. Fixed assets acquired after 1989 are expensed.

Life memberships paid since 1977 are recorded at the fee in effect at that time. There are 38 life members.

3. Fixed Assets

	1990	1989
Cost	$16,748	$16,748
Accumulated Depreciation	10,992	9,074
Net book value	$ 5,756	$ 7,674

4. Funds

	1990	1989
Baldwin Memorial Fund	$ 358	$ 358
Seedathon	1,423	964
Anne Hanes Memorial Fund	815	790
Alfred Bog	1,519	4,536
	$ 4,115	$ 6,648

The Ottawa Field-Naturalists' Club Financial Statements Year ended September 30, 1990

THE OTTAWA FIELD-NATURALISTS' CLUB
BALANCE SHEET
SEPTEMBER 30, 1990

	1990	1989
Assets		
CURRENT ASSETS		
Cash	$191,892	$149,649
Accounts receivable	16,874	14,054
Interest receivable	2,159	1,577
Prepaid expenses	1,394	1,395
	212,319	166,675
FIXED (Note 3)	5,756	7,674
LAND – Alfred Bog	3,348	3,348
	$221,423	$177,697
Liabilities, Funds and Members' Equity		
CURRENT LIABILITIES		
Accounts payable	$ 69,475	$ 38,573
Deferred income	10,176	11,700
	79,651	50,273
FUNDS (Note 4)	4,115	6,648
LIFE MEMBERSHIPS	6,000	6,000
MEMBERS' EQUITY	131,657	114,776
	$221,423	$177,697

THE OTTAWA FIELD-NATURALISTS' CLUB
STATEMENT OF MEMBERS' EQUITY
YEAR ENDED SEPTEMBER 30, 1990

	1990	1989
EXCESS INCOME (EXPENDITURES)		
Ottawa Field-Naturalists' Club	$ 6,024	$ 366
The Canadian Field-Naturalist	6,177	9,092
	12,201	9,458
OTHER INCOME (CHARGES)		
Donations and grants	3,066	13,083
Trail & Landscape Index	–	–
Records and tapes	1,614	1,365
	16,881	23,906
MEMBERS' EQUITY, BEGINNING OF YEAR	114,776	90,870
MEMBERS' EQUITY, END OF YEAR	$131,657	$114,776

THE OTTAWA FIELD-NATURALISTS' CLUB
STATEMENT OF OPERATIONS – OFNC
YEAR ENDED SEPTEMBER 30, 1990

	1990	1989
INCOME		
Membership fees	$13,603	$13,889
Trail & Landscape		
Subscriptions	440	440
Back numbers	89	16
Interest	3,535	2,521
Other sales	(405)	(650)
	17,262	16,216
EXPENSES		
Trail & Landscape		
Printing	4,265	3,821
Circulation	1,125	284
Production	158	204
Honorarium	660	660
Comittees (Net)		
Excursions and lectures	(2,016)	(75)
Membership	1,560	1,337
Macoun Club	862	1,112
Conservation	98	66
Birds	96	97
Education and publicity	118	57
Computer	112	337
Affiliation fees	30	230
Office assistant	643	790
Office supplies and expenses	2,265	2,678
Special publications	(656)	1,304
Depreciation	1,918	2,948
	11,238	15,850
EXCESS OF INCOME OVER EXPENSES	$ 6,024	$ 366

THE OTTAWA FIELD-NATURALIST'S CLUB
STATEMENT OF OPERATIONS – CFN
YEAR ENDED SEPTEMBER 30, 1990

	1990	1989
INCOME		
Membership fees	$ 9,500	$ 9,500
Subscriptions	19,938	24,883
	29,438	34,383

Publication		
Reprints	6,894	13,029
Plates and tab settings	1,138	6,477
Extra pages	34,834	20,801
Back numbers	1,552	557
Interest	14,137	10,086
Exchange	784	2,612
	88,777	87,945
EXPENSES		
Publishing	60,264	53,920
Reprints	4,619	5,859
Circulation	6,330	7,128
Editing	678	1,819
Office assistant	3,913	3,656
Office supplies	809	4,391
Honorarium	2,080	2,080
Equipment	3,907	–
	82,600	78,853
EXCESS INCOME OVER EXPENSES	$6,177	$ 9,092

Committee Reports for 1990

Publications Committee

The role of the Publications Committee is to supervise, and to advise Council on, the Club's publications, for which purpose it met four times in 1990.

Six issues of *The Canadian Field-Naturalist* were published in 1990: Volume 103, Issues 1 to 4, and Volume 104, Issues 1 and 2. The 1004 pages of the six issues contained 60 regular articles, 35 COSEWIC reports on the status of endangered species, 40 notes, 195 book reviews, 672 new titles, 2 commemorative tributes, and 26 pages of news and comment. The committee expresses its thanks to Dr. Francis Cook for his major effort in bringing the journal substantially back on schedule, and to Mickey Narraway for the assistance she rendered to him.

There were substantial changes in the panel of associate editors, with the retirement of Drs. McAllister and Bousfield, and the appointment of Dr. B. Coad, Dr. E. Godfrey, Mrs. D. Laubitz and Dr. B. McGillivray. In addition, Dr. R. Campbell has been appointed, beginning in 1991. The Club, in 1990, purchased a computer for the editor of *The Canadian Field-Naturalist*.

The Canadian Field-Naturalist is distributed not only to the membership of the OFNC, which is largely in the Ottawa area, but also to many institutions and non-member subscribers which assures it a wide distribution both in North America and abroad. The non-member individual subscribers comprise both professionals and amateurs with vocations, or simply an interest, in natural history. The geographical distribution of the non member subscribers is shown in the following table:

	Institutions	Individual
Canada		
Nfld	15	3
NS	13	16
PEI	3	3
NB	13	10
Que	28	9
Ont	87	51
Man	15	10
Sask	11	9
Alta	28	43
BC	18	25
NWT	10	5
Yukon	3	5
Sub-total	224	189
USA	282	69
Other Foreign	52	7
TOTAL	578	265

Under a new editor, Elizabeth Morton, Volume 24 of *Trail & Landscape* was published in 148 pages and 4 issues. The somewhat reduced paging was due mainly to a reduction in the number of manuscripts submitted. 1990 also saw the appearance of the Green Line, a one-page, newspaper supplement to *Trail & Landscape* that is coordinated by Michael Murphy and is largely concerned with environmental issues. Elizabeth Morton resigned as editor of *Trail & Landscape* with completion of Volume 24; Fenja Brodo has been appointed as her successor. Peter Hall and Bill Gummer were reappointed as associate editors for 1991.

The successful publication of these two journals is made possible through the efforts of a large number of people: editors, business managers, associate editors, reviewers, indexers, production and mailing teams. The Committee expresses its thanks to all of them.

RONALD E. BEDFORD (Chairperson)

Membership Committee

The total paid-up membership as of December 1st, 1990 was 1172. Of this number, 132 were new members. Of these 74 were individual memberships and 57 were family memberships. Assuming an average of two members per family membership, the total number of members in the Club is estimated at 1576.

The following chart [page 435, top] summarises the membership distribution. The figures for 1989 are in brackets.

There are a total of 125 names on the volunteers list.

The Membership Committee and the Excursions and Lectures Committee again co-hosted a successful New Members' Night on November 9th. Approximately 80 people, including several honorary members and members of Council, enjoyed an evening of information about the Club's activities and history, as well as wine, cheese and other refreshments, in the Salon of the Canadian Museum of Nature.

DOREEN WATLER (Chairperson)

Macoun Field Club

The committee continues to provide strong leadership for the Macoun Field Club. Indoor meetings and field trips are planned throughout the school year for Juniors (Grades 4-6) and Intermediates (Grades 7-8) on Saturday mornings. Seniors (high-school students) have meetings every Friday afternoon. Members of the committee are very much involved with "Macouners". They have divided up responsibility for planning and leading field trips, and attending meetings of the various groups. While the leadership of the Club has become more strongly based on the committee,

1990 Paid-up Membership in the OFNC

Type	CANADA Local	CANADA Other	FOREIGN USA	FOREIGN Other	Total
Individual	431 (482)	178 (214)	44 (43)	6 (6)	659 (745)
Family	368 (351)	34 (29)	2 (1)	0 (0)	404 (381)
Sustaining	41 (15)	2 (0)	2 (0)	0 (0)	45 (15)
Life	15 (16)	18 (17)	4 (4)	2 (2)	39 (39)
Honorary	15 (16)	9 (8)	1 (1)	0 (0)	25 (25)
Total	870 (880)	241 (266)	53 (49)	8 (8)	1172 (1203)

the activities have remained much the same over the Club's forty-three year history. Talks are given by outside speakers on a diversity of natural history subjects, and regular field trips are taken to explore local habitats. Over the last year, special projects have included the building and placing of bluebird nest boxes, and examining the effects of the urban environment on the distribution of lichens on trees. Membership at the Junior and Intermediate levels is healthy, but more Senior members are needed. The committee would also welcome more individuals willing to assist with the leadership.

BARRY BENDELL (Co-chairperson)

Finance Committee

The committee met five times during the year. The items on the agenda that took most of the time were the fee increase, the impact of the GST upon the Club, and the resignation of the Treasurer whose work took him to Nova Scotia. Other items considered were a microcomputer for the editor of the *The Canadian Field-Naturalist*, an offer to disseminate this journal on a CD-ROM, and a special mailing to announce the "Brazil night" to local members.

FRANK POPE (Chairperson)

Excursions and Lectures Committee

The Excursions and Lectures Committee organized nine evening meetings with speakers making presentations on a wide variety of subjects. It also hosted another successful Soiree – a social evening where the Club rewards members who have made a special contribution to our objectives. New Members' Night was again co-hosted with the Membership Committee.

In the local area the committee arranged six full-day and twenty-six half-day field trips. In addition there were nine evening trips and one overnight trip. Seven bus trips, to places outside the local area, were scheduled, but three were cancelled due to lack of interest.

The committee set up an extended five-day trip to New Jersey to coincide with the spring migration. This was the first time for this trip and, although it went well, the experience gained should mean an even greater success in 1992, when we do it a second time. In particular, several economies were possible that enabled the committee to refund the participants a major part of the cost.

These trips reflect the range of interests of Club members. Bird-oriented trips dropped somewhat from 44% to 32% of the total, while general interest trips rose from 28% to 38%. Botanical trips also rose from 16% to 20%. The 10% balance was devoted to amphibians, insects and geology.

There was one sad note to the year. Edith Ikeda, a longtime, hardworking and ceaselessly cheerful member of the committee died after a long illness. She will be missed.

The Chairman would like to thank the committee members and all the trip leaders for their hard work and willing cooperation.

ROY JOHN (Chairperson)

Executive Committee

The Executive organized and managed the Scott House Workshop in February and met in March and August, 1990. The following major activities were implemented in 1990:

1. *Scott House Workshop*: The President suggested to Executive and Council that a special review of club activities might be useful in light of increased public concern and interest in environmental problems and solutions. About 25 Club members attended an all-day workshop held at Scott House on Gamelin Blvd. on February 10, 1990.

At a plenary session, thirty-four issues were identified and organized into four areas of concern: policies and objectives, communications, club structure and action-implementation type issues. Four working groups, one for each area of concern, discussed and developed recommendations to deal with these issues. A final plenary session listened to group findings and provided feedback.

The results were collated and sent to appropriate Committees for review and recommendation to Council. It is hoped that the Workshop will result in some useful new initiatives over the next year.

2. *Hosting the 1993 FON Annual General Meeting*: The Federation of Ontario Naturalists (FON) asked the OFNC to host a future Annual General Meeting (AGM). Executive recommended to Council and Council approved the hosting of FON'S 1993 AGM. Executive has formed a steering committee to start planning and a letter was sent to FON confirming our commitment, in May 1990.

JEFF HARRISON (Chairperson)

Education and Publicity Committee

The committee met seven times in 1990. Speaker and display volunteer lists have been compiled and are now up to date. The committee chairperson's binder is complete. It provides background information on the OFNC and the committee. The OFNC club flyer has been revised.

Seven local events were found suitable for the club display, which was manned by club volunteers. These included Greenprint Day, the Photography Fair and the Ottawa Duck Club's annual nature and wildlife art show.

Five requests for slides and speakers were filled; two are ongoing for 1991. An OFNC slide show suitable for dis-

play and live presentation is being developed. The committee made its first presentation of the FON'S Seniors for Nature "Spring Wildflowers" slide show.

OFNC judges, coordinated by a committee member, awarded three prizes this year, at the Ottawa Regional Science Fair.

The sale of club articles amounted to approximately $550.00.

DEIRDRE FURLONG (Chairperson)

Conservation Committee

The Conservation Committee had ten regular monthly meetings during 1990. Also, committee members met on a number of occasions to deal with specific issues or, through field trips, to learn more about the issue.

Some of the highlights of the year included the following: In cooperation with the Friends of the Farm (Central Experimental Farm), site and planting plans for the wildlife garden were prepared, a "sod-turning" ceremony was held in June and garden volunteers had an organizational meeting in November. Together with other environmental groups, members of the committee worked through both planning and legal processes to try to protect significant wetlands in the region, including the Constance Creek wetland (partially destroyed by a golf course development) and the Leitrim wetland (threatened by housing and industrial development). The fate of both of these wetlands remains in doubt and the process reveals serious shortcomings in Ontario's Planning Act and other regulatory controls of land-use planning and development. Other lands within the Regional Municipality of Ottawa-Carleton which are proposed for development and where the conservation committee has advocated the protection of key significant natural features and wildlife corridors include Carsons Woods (CMHC lands in Ottawa and Gloucester) and Clyde Woods (Clyde-Merivale area). The committee provided input into a number of planning efforts at various levels of government, such as the federal Green Plan and Ontario's management plan for Carillon Provincial Park.

Despite the high degree of public awareness and concern for the environment and a lot of hard work by dedicated conservationists, the committee feels that we had limited success in protecting natural areas during 1990. It is hoped that in 1991, politicians, developers and public servants will better demonstrate that they are sincerely listening to and addressing the public desire for the protection of our remaining green spaces.

DON CUDDY (Chairperson)

Computer Management Committee

The committee ensures the efficient and controlled use of the computer assets of the Club. It maintains and improves existing systems and increases awareness of how the computer can help the Club meet its objectives.

Here are some achievements:

In response to the Scott House Workshop, we proposed ways to use the Club's computer assets and resources in Club communications: computer communications (eg. electronic mail) defeat both time and distance. We prepared a survey for distribution to Council and committee members in early 1991, to help evaluate the value of computer communications in the Club.

We sourced and priced recycled paper to help the Club with its decision to convert to using recycled paper. Before recommending its use, we tested different grades of fanfold recycled paper in the Club's (membership system) dot matrix printer. We confirmed that print quality is adequate and, even the lower grade paper feeds through the printer without damage to the paper or the printer.

We drafted procedures for Club-specific use of FASTBACK PLUS and Calendar Creator Plus.

We completed a detailed design of the new membership system. Committee members have been coding and testing its component modules. Also, we designed a procedure that converts data from the existing database structure to the new, to reduce the amount of manual data re-entry.

We revised inventory control sheet (supplies) to simplify recording and make forecasting needs more accurate.

An expanded Computer Management Committee evaluated the Editor of *The Canadian Field-Naturalist*'s word processing needs. The committee advised Council about prospective solutions and arranged the purchase of a computer, dot matrix printer and software.

The committee provided systems maintenance and/or technical support to each of the Club's three computer systems. We kept software current through upgrading and we successfully negotiated the free upgrade of the Trail & Landscape computer to a 386SX.

SUZANNE M. BLAIN (Chairperson)

Birds Committee

The committee devoted most of its energy to maintaining the regular bird related activities of the Club. These included preparing seasonal summaries of sightings for Trail and Landscape, co-ordinating the club feeders, reviewing documentation of unusual sightings, and running the spring and fall roundups.

The Christmas Bird Count has been organized again as a co-operative project with the Outaouais club and with co-compilers. We hope that increased advertising will improve the turnout of OFNC members at the post-count meeting.

We continued participation in the Ontario Rare Breeding Bird Program with the completion of a survey of pertinent historical records and the collection of another set of seasonal observations.

The Bird Status Line and Rare Bird Alert systems worked well. It is particularly important to note that the status line logs are the only base data on observations that are available to researchers and authors now that the Shrike data collection process has stopped.

The Fall seedathon was again successful and this year for the first time in some years, the Club promoted the Baillie Birdathon in the spring.

GORDON PRINGLE (Chairperson)

Awards Committee

Basing its recommendations for OFNC awards on nineteen nominations and on the "carry-over" list (mostly aimed at Honorary Memberships) the committee recommended only three awards to Council. It was felt that 1989 achievements did not justify either the Conservation Award or the Anne Hanes Natural History Award. Council accepted this position and approved the following awards, presented at the Soiree on 27 April.

(1) Honorary Membership: Dr. A. J. Erskine – for his work as an Associate Editor for ornithology with *The Canadian Field-Naturalist*, and as a professional scientist

concerned with bird migration and other subjects, with experience across Canada.

(2) Service Award: Dr. Joyce M. Reddoch – for her contributions to the Club as Editor of *Trail and Landscape*, as a strong Conservation Committee member, as a Council member, and as author of many articles of interest to Club members.

(3) Member of the Year Award: Deirdre Furlong – for her success in getting Education and Publicity Committee back on a solid and active basis.

One nomination was made for an outside award but was not successful.

The President's Prize, although not part of this Committee's responsibility, is included here by Council request. The 1989 prize was presented by President Jeff Harrison to Michael Murphy for his outstanding commitment to many Club activities in the conservation area.

The committee is still concerned about the small number of nominations.

BILL GUMMER (Chairperson)

Book Reviews

ZOOLOGY

Food Hoarding in Animals

By Stephen B. Vander Wall. 1990. University of Chicago Press, Chicago. xii + 445 pp., iluss. cloth U.S. $76.00, paper U.S. $29.95.

In the long traditions of both natural history and literature (from the fables of Aesop to the plays of the Capek brothers), food hoarding justifiably has been and remains a topic of prime interest. Vander Wall has generated what surely will serve as the standard reference on hoarding for some time. Eight of the 11 chapters consider aspects of hoarding while three focus on taxonomic surveys of mammals, birds, and arthropods. Food may be hoarded in larders or scattered, and may serve the present or following generation. The temporal use of stored food ranges from daily to seasonal. The nutritional effects can often be seen in reproductive output, including unique cases such as male MacGregor's bowerbirds in which stored food enhances courtship alone. Various scenarios are presented for the evolution of hoarding, along with specializations for food transport such as cheek pouches. Especially interesting are communal hoarding and the co-evolution of hoarders and their food, as in the case of nutcrackers and stone pines. As humans know from their enormous annual losses in granaries, caches can be lost, and hence require protection, from decomposers, robbers, and inaccessibility. Among the most stimulating findings in this area is that fungused seeds are preferred, perhaps due to their enhanced nutritional value.

Two chapters provide excellent examinations of factors influencing hoarding behaviour and cache recovery. Hoarding is susceptible internally to the genotype, ontogenetic stage, sex, and hunger of an animal, and environmentally to such cues as light, temperature, social stimulation, and availability of food. Cache recovery depends on different cues in different species and on memory capacity, as demonstrated in a number of recent and elegant experiments. Two other chapters survey the impact of hoarding on plant dispersal and community structure. For the great diversity of plants involved there are costs and benefits to dispersal via hoarders. An intriguing comparison is made of estimates of the rates of spread of various trees in North America during the Holocene following glaciation based on pollen data and the activities of hoarders. Of the three taxonomic chapters, that on arthropods is perhaps the most interesting since less of this material has been covered in earlier chapters.

Unlike many recent works in behavioural ecology, this book achieves a happy balance of attention to physiological, ethological, ecological, and evolutionary aspects of the topic, and all in a clear style. The text is well organized and illustrated, although the margins are wastefully wide, and thorough indices and appendices are attached. There is an appropriate inclusion of explicit models (e.g. of the evolution of hoarding) and of hypothesis testing (e.g. on the development time of eggs and provisioning in wasps). The "Canadian content" is high, given the large number of our own species which take advantage of seasonal abundances of food, with studies varying from gray squirrels in Mount Pleasant Cemetery, Toronto, to beaver in Wood Buffalo National Park. Overall this book should appeal to a wide readership.

PATRICK COLGAN

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Those of the Forest

By W. B. Grange. 1989. Reissue of 1953 edition. Willow Creek Press, Wautoma, Wisconsin. 314 pp., illus. U.S. $19.50 + U.S. $2 shipping.

Wallace Byron Grange first published his fictional story in 1951 for which he received the John Burroughs Association award for distinguished nature writing. His story "Those of the Forest" is truly a labour of love from a man who spent a lifetime as a biologist/naturalist.

Grange centres his story on the web of life through the eyes of a simple Snowshoe Hare. His story relates the cycle of life and the interrelationship of all living things on a time continuum through the eyes of his main character. Life struggle is presented philosophically throughout the book questioning many ecological precepts. His questions are profound, his answers succinct, such that he easily draws the reader into the realization that we are all a part of the delicate chain of life. He surmises that throughout the ebb and flow of life, the life of one living creature can readily affect that of another.

Grange transfixes the reader in the realm of the rabbit by his rich imagery and prose. He delights the imagination. He easily conveys the cycle of the sea-

sons such that the reader can visualize the moment. This book is a canvas painted by an expert wordsmith. This is the beauty of his work as the story could have been easily reduced to a two dimensional treatise of facts and figures. His appeal rests in the beauty of his prose which transcends a technical topic to render it sensible to a popular readership.

I highly recommend this popular classic work to anyone's reading list.

G. D. MADIGAN

2449 Autumn Hill Crescent, Gloucester, Ontario

The Natural History of Weasels and Stoats

By Carolyn King. 1989. Comstock Publishing Associates/ Cornell University Press, Ithaca, New York. 253 pp., illus. U.S. $26.50.

The weasels (*Mustela* spp). are a fascinating group of carnivores that until recently, received little attention from most scientific communities. In the Series Editor's Foreword, Ernst Neal states that the purpose of this natural history series is to bring together available literature, including recent research, and explore the subject matter in greater depth than has been done in other recent natural history books. King has done an admirable job in accomplishing this objective.

King's book provides a highly informative and detailed account of the three weasel species common throughout the northern temperate and boreal zones: *Mustela nivalis, M. erminea*, and *M. frenata*. The text is easy to read, yet King maintains the technical quality required by the scientific community. A work of this caliber can only be written by an individual with vast experience and understanding of the subject, which attests to King's 20 plus years of research devoted to these small carnivores. Her thought-provoking discussions open doors to many concepts requiring additional consideration and research. Although there are a few peculiar statements, the vast majority of text is sensible and logical. The tables and figures provide a great deal of additional information and are generally easy to read. Although the line drawings are of varying quality, they adequately serve the purposes for which they were intended. The author did an excellent job presenting pertinent information on these species throughout their geographic range. It may appear that portions of the text are biased toward studies conducted in Europe, Asia, and New Zealand, however, I believe it is appropriate as most research, including King's has occurred outside of North America.

The book is divided into 14 chapters that follow a natural and highly organized progression from a summarization of evolution, morphology, and physiology to their relationships with man. Additional chapters include discussions of molt functions and patterns, the importance of body size, food habits, hunting behavior, impacts on prey populations, home range, reproduction, population dynamics, and probably the most stimulating chapter involved thorough discussions of sexual dimorphism, delayed implantation, and competitive exclusion. Although there is a great deal of information about habitat use, it is scattered throughout the text. It would have been advantageous to summarize the available information as an additional chapter.

The book contains few typographical errors. Although the naming convention used for classifying weasels in the book is clearly outlined in the preface and Table 2.1, it was not strictly adhered to (e.g. least weasel was interchanged with common weasel, weasels were referred to as "alpine" and "arctic" weasels). In calculating daily food requirements for common weasels and foxes, the initial biomass should be 5 kg, not 50 kg as presented. Figure 4.4 is upside down. Additionally, tables do not follow the same format throughout the book, nor are tables or figures necessarily presented in the order initially addressed in the text. However, these errors are trivial and do not detract from the overall outstanding quality of the book.

The index is workable, providing easy access to major topics and their associated subtopics. The bibliography is very complete and will become an excellent reference for individuals interested in obtaining additional information about these amazing carnivores. This reasonably priced book would be a valuable addition to the library of most mammalogists, behavioral ecologists, and naturalists, and a must for carnivore ecology enthusiasts.

JERROLD L. BELANT

State University of New York, College of Environmental Science and Forestry, Adirondack Ecological Center, Newcomb, New York 12852

North American/World BirdBase 2

By Santa Barbara Software Products, Santa Barbara, California. U.S. $99.00.

Birdbase 2 is an upgrade of the *WORLD Birdbase*. The earlier product was reviewed in *The Canadian Field-Naturalist* 104(2): 314–316. It is a database software computer program for the bird lister. It is designed for the easy recording of birding records in the form of lists. It has three main features.

First, it contains a list of all the birds in the world. The list in Birdbase 2 is from James Clements' latest edition of *Birds of the World: A Checklist*. The list includes English names, in the North American style, the scientific names, the family names, and a number for each species.

Second, it contains a database manager that allows for the search of a name found on the world list. Once a name is found it can then be put into any one of nine specialized lists, such as life list or country list. The manager can slso be used for a wide variety of searches of lists and for many other standard data manipulation procedures.

Third, it contains print utilities that allow for the printing of the lists.

Birdbase 2 is a minor upgrade from *WORLD BirdBase*. The newer version makes it easier to change the names in the master list. The renaming, splitting, and lumping of species are now straight forward. More lists are now possible. There is no limit on the number of sightings that can be entered.

There is a new feature that allows the user to input the names of species from other groups. This enables the user to keep a life list of mammals or of plants, for example. Such input appears to be straightforward, but involves a lot of very tedious typing. The species need to be typed into the computer and the lists must be formatted very carefully. The software does not prompt you for input into a template. This feature is not documented in the manual, but is found in a Readme file that is associated with the utilities disk. For major groups it would make more sense for Santa Barbara Software to start selling files containing the information. For example a list of the mammals of North America could be developed. Over time, other major groups could be made available.

My idea of a lifelist record has been formed by the way such information is typically stored in a file card. A record contains information on the species' name, the location of the observation, the date, and possibly some comment on the circumstances surrounding the special event. On the computer screen I expect the same format. *Birdbase 2* does not present a lifelist in this way. It presents a list of birds, with the other information hidden in other files. I find this awkward. I would much prefer the fild card approach.

There are too many key strokes necessary to input a new life list record. The menu system is quite useful, but is somewhat awkward. The software is not mouse compatible. It would be ideal to have the software adapted to a point and shoot approach that is now possible with Windows 3 running on a DOS system.

The software has one very unfortunate problem. It is shipped with only one size of floppy disk. And this floppy must be inserted in the A drive for the software to work. Even if the software is transferred to a hard disk, one specific disk must always be in the A drive. What happens if your A drive is for the other sized floppy? Well, you are out of luck until you can get the company to send you the correct size disks. This approach was used for copy protection. I do not like copy protected software but I understand the need for it. However, in future the versions of the software should either come with both sizes of floppies or have a utility that enables the user to select the drive in which the floppy is placed.

The software operates only on IBM-compatible computers. It works best in machines with 640 K of RAM or more.

I repeat my comment from the previous review. The list of the birds of the world is superb and very useful. But I find the database manager to be awkward. As a result I have dumped all the names into a commercial software package, WATFILE + from Watcom Products of Waterloo. This gives me more flexibility. I can design the lists more to my personal satisfaction.

Santa Barbara Software is well into its way to designing a useful and needed product. It would be great to see "BirdBase 3" operating under Windows 3, with all the east of use that this would entail. It is probable that the next upgrade of the software will probably see the light of day well before this review gets published in this journal.

For the beginning computer user who wants to keep life lists in a computer file, *BirdBase 2* is well worth the money. For the more advanced computer user who already uses a database manager, the world list of birds is a valuable product. BirdBase has been around for several years now. It appears that Santa Barbara Software is a viable entity that will continue to develop and enhance the software. I look forward to future versions.

PAUL F. J. EAGLES

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Field Guide to the Birds of Britain and Europe

Jim Flegg. 1990. Cornell University Press, Ithaca, New York. 256 pp., illus. Cloth U.S. $43.50; paper U.S. $19.95.

In the past I have avoided the debate between artwork and photographs as illustrations for guides. This new contribution to the already crowded list of European Field Guides will force the issue. I prefer, by a wide margin, the use of artwork and I can use this book to explain why.

The photographs, taken by two famous British photographers, David and Eric Hosking, are, for the most part, excellent. The size varies but these photographs are generally around 2½" by 2¼" to 3½"; adequate size for good definition. The printing is first rate (with two exceptions) with accurate color rendition and precise definition. Normally there is one photo per species. So the ducks are represented by a male in breeding plumage, the raptors by perched birds, and the gulls by a single plumage. Thus eclipse males and female ducks, raptors in flight, and the complex sequence from juvenile to adult plumage in gulls are mostly unillustrated. While some of the photographs are superb they are not very useful for identifying a particular species. The photograph of the Whitethroat, for example, is a crystal clear flight shot; an amazing technical achievement. But it is difficult to compare with the adjacent photograph of a perched Lesser Whitethroat. Finally a photo is of one individual and can never portray the combination and generalisation of characteristics that a good, knowledgeable artist can work into a painting.

The photographs are accompanied by a short text and a small range map. I checked several of the maps against nest record data and found some errors. For example, Alpine Chough and Raven both have more extensive ranges than shown, while those of Egyptian and Griffon Vultures are overly optimistic. The text is short and crisp and covers the essentials in a logical fashion, although it is not enough to be useful in the hard-to-separate cases.

Also included is a 12-sector pie chart of seasonality, which is coded by depth of color into three levels of abundance; not seen, fairly frequent, and most abundant. This is a useful innovation when used in conjunction with the range maps.

There were a few species not covered in the text that really should, at least, have been listed. Birds like Marbled Teal and Oriental Cuckoo nest within the boundary of the range map used. Rarities like Yellow Warbler and Pallas's Sandgrouse occur often enough to warrant at least listing in a rarities section.

So what does this book add to field guide literature that makes it worth buying? That is a difficult question to answer directly. It is easier to say if you are buying your first European field guide I recommend you purchase a "Peterson"[1]. It will be more useful for identifying new birds. If you want a second reference I suggest one of the many European guides that use artwork[2]. If you have two or more guides already then you can think about adding this book. If you simply like magnificent photographs you will really enjoy this book.

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[1]A Field Guide to the Birds of Britain and Europe by R. Peterson, G. Mountfort and P. Hollom. Collins, London.
[2]For example, The Collins Guide to the Birds of Europe with North Africa and the Middle East by H. Heinzel, R. Fitter, and J. Parslow – See the book review by H. Ouellet Canadian Field Naturalist 104 (1): 146.

Guide to the Birds of Madagascar

By Olivier Langrand, illus. by Vincent Bretagnolle, translated by Willem Daniels. Yale University Press, New Haven, Connecticut. 364 pp., illus. U.S. $50.00.

Birds of Madagascar is more than a simple field guide. It begins with a section on the island's habitats which not only includes a brief description but also comments on the current level of threat. There is a general discussion of the 256 species of avifauna found on the island, of which 52% are endemics, coupled with an analysis of the various bird communities. For the visitor there is a useful section on the 17 best sites to visit, with practical information on access and so on, plus a table of the birds to be found at each site.

The field guide section begins with some very brief descriptions of a few offshore species such as albatross, petrels, and shorebirds, before moving into the main field guide portion. This is organised in the older style, with all the plates in the centre of the book. While this is not as convenient as the more modern style, with text on the left and illustrations on the right, it does allow the author to include as much text as required. Originally written in French, this edition is the English translation. The quality of translation is excellent, capturing the idiom of the language as well as the literal sense. The text itself is well organised, clearly written, and accurate. Where appropriate it gives descriptions of adult and juvenile, male and female, and colour morphs. These descriptions include the important differences that are so useful in field identification. Under each

species there is a specific identification section which gives comparisons with any similar species. There are also sections on behaviour, voice, habitat, diet, and distribution.

In addition, there are 255 distribution maps at the rear of the book. Unfortunately as these are numbered not labeled, it is necessary to look up the sequential species number in the text to know which distribution is represented. Similarly the general map, which is meant to show the reader the important locations, is a simple coastal outline with only rivers marked. It has a reference grid and a table gives the corresponding reference location for the places given in the text. This is difficult to use, especially for the visitor, as each location can only be assigned to a grid square. Comparison with other atlas maps is further complicated by the use of different spellings for place names.

The plates cover all 256 of the species in the book. At first glance they seemed quite professional and technically competent. However a closer look reveals a surprising number of problems. These range from the incorrect labeling of the male and female of the Painted Snipe to a more general pale colouring of many species. For example the Common Waxbill (*Estrilda astrild*) is so pale it looks more like a Red-eared Waxbill (*E. troglodytes*). This, however, is an escape and not an important part of the fauna. Many of the shorebirds are both pale and too gray (Little Stint, both European godwits) but these are well illustrated in many other guides. The main problemis that the endemics are pale or over gray too. This is much more serious as the author's main intent is to inform the reader of these birds. For example, the Mascarene Martin should be a more rich, sooty brown than shown. The Gray-headed Lovebird is a deeper green than depicted (at least for the *Agaponis cana cana* subspecies). Both species of Vasa parrots should be darker and should face the other way so that the colouration of the underparts could be shown. There are a host of other details where parts of a bird are too big (many bills), too short (the Hoopoe's crest, many tails), the wrong colour (the Black Kite is almost as red as a Red Kite), or are not quite the right shape.

These are not printing problems as illustrations of which I am critical appear side by side with ones that range from satisfactory to excellent. Much of my criticism is directed at the passerine plates as the artist does a much better job of waterbirds than most of the others. In fact, I like his breeding Cattle Egret better than those in any other field guide. Fortunately the text is accurate and does not support the errors in the plates. (Although the use of "Madagascar" Bee-eater for *Merops supercilosus* is confusing as this species is distributed in Africa and Asia and not just Madagascar).

Despite the problems I have with the maps and the plates I recommend this book as an interesting purchase and a valuable contribution to ornithological literature. But I would advise the buyer to read the text carefully and rely on it rather than the plates.

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The Reintroduction of the White-tailed Sea Eagle to Scotland: 1975-1987

By John A. Love. 1988. Research and survey in nature conservation series No. 12, Nature Conservancy Council, Peterborough, Great Britain. 48 pp., illus.

This monograph chronicles the years of work that are necessary to re-establish a species eradicated through neglect or active persecution by man, summarizing the results of the project and the natural history of this reintroduced population. The efforts detailed here closely parallel the reintroduction programs for Bald Eagles and other species in North America.

The experience in Scotland emphasizes the importance of healthy donor populations that can serve as a source of progeny for depleted populations. Although captive propagation was considered and briefly tried in the early years of the project, the availability of eaglets from northern Norway significantly reduced the difficulty and expense of the reintroduction program.

It was also evident from the report that many people contributed to the project. Cooperation among project personnel, volunteers and other cooperators from the local to the international level was essential to the success of the reintroduction program, as it so often is in a project of this scope.

Reading this report will benefit those initiating reintroduction programs, reducing time wasted in trial by error. The account will also be appreciated by those who enjoy a conservation success story.

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Oklahoma Herpetology: An Annotated Bibliography

Charles C. Carpenter and James J. Krupa. 1989. Oklahoma Museum of Natural History Publication, University of Oklahoma Press, Norman. 258 pp. U.S. $22.95.

What a useful volume! And what a shame that something similar will probably never appear in Canada, where nonfish and nongame wildlife programs are all but invisible. Produced by the Oklahoma Museum of Natural History in cooperation with the Oklahoma Biological Survey and the Oklahoma Department of Wildlife Conservation's Nongame Program, some would consider this book a model of how an annotated bibliography should be compiled and arranged.

Including 1536 references to Oklahoma's amphibians and reptiles spanning the years 1823 to 1987, this work also provides: 1) a Checklist of species found in the state; 2) a Genus and Key Word Index, and 3) an English Names Index. In the main body, the often-used practice of assigning each citation a unique sequence number is followed . The citations contain the following information: author, date of publication, title, name of journal or book (with editors when necessary), publisher (if it isn't a periodical), and an annotation. The annotations themselves frequently begin with a brief description (where it was felt that the title failed to convey the pertinence of the article), and are followed by 1) a string of relevant Key Words, and 2) a list of genera appearing in the article. Investigators looking for General References will be pleased to know that this is one of the Key Word categories, that these are broken down by subject at the end of the index, and that collective phrases (such as "All Caudata") are often used to replace genera listings, thus making it easier to scan the main body for a particular genre of information. This type of easy eyeballing and cross-referencing makes such efforts of great utility to both scientists and field-naturalists alike.

The Genus and Key Word Index is arranged by genera in the typical taxonomic order of Amphibia first, Reptilia second and the Key Words serve as subject headings under each genera. For each subject, all relevant citations, in numerical order, are listed. The only drawback to the numbering approach to cross-referencing is apparent here, where all numbers under a particular subject heading have to be searched in the citations with no way of a priori eliminating those irrelevant to your needs. Another bonus, however, is that the Introduction lists all sources searched so you know where NOT to look if you're looking for something that you think is missing.

Because Oklahoma encompasses a broad range of physiographic and ecological areas from piedmont in the west, through central prairie to the Arkansas River valley and parts of the Ozark plateau in the east, students of midwestern herpetology will probably be most thrilled with this handy reference – but they'll have to pay since the volume is in hardcover; why a reference as esoteric as this would be produced in such a way as to drive up the cost and potentially cut down the market is anybody's guess, but for some, its quality will clearly warrant the price.

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Reptiles and Amphibians

By Robert E. Wrigley. 1990. Wilderness Album Series, Hyperion Press, Winnipeg. 39 pp., illus. $5.95.

The series is designed to offer nature stories for children plus scientific information and line drawings. In this case it is accomplished by providing short (approximately 300 word) story-like accounts of each 38 selected species of North American reptile and amphibian, which highlight certain life-history aspects of the taxa in question. A fair amount of biological information is subsumed within these stories, which are each followed by a short list of more detailed scientific considerations; taxonomy (class, order, family and scientific name), size, distribution, habitat, food and color. The format is two stories per page, augmented by line drawings of the animals on the facing page.

The line drawings range from fair to excellent, but in general are very good, with proportion, color and scalation patterns accurately represented (this isn't surprising since I recognized some of the drawings from well-known photographs and illustrations in the herpetological literature). Most animals are depicted in a recognizable aspect, although the Hognose Snake is an exception in being rendered in the ubiquitous "sensationalist" pose of upside-down feigning death – this may be an unwarranted criticism given that the series does not purport to be an identification manual. The appended color descriptions provide a guide by which the drawings could be colored in by the reader if he/she so desired (colored pencils would be more appropriate than crayons given the detail).

The scientific content of both the stories and lists following them is exceptionally comprehensive and

accurate for a children's book, is presented in a fashion that is neither overwhelming nor condescending, and should serve to stimulate further interest in these creatures and some of their peculiar habits.

I liked some of the stories, and found others mundane, but the kids I showed it to all thought they were interesting. I found that children needed fairly high reading comprehension (mid-late primary school), but that even then there were some scientific terms which appeared in the text without definition that eluded everyone (e.g., cloaca). In order to completely evaluate this offering, one would have to know at which age group it was aimed. The information content is high enough for late primary, but the stories may be too simplistic for that level. Thus, this is also not a criticism per se, only a quandry to be weighed by the potential purchaser. One approach would be to buy it for the younger folks, who could color it and gain progressively more from the stories as their reading comprehension and biological background knowledge grew.

Notwithstanding, I believe the approach this series takes is an excellent way to engender interest and appreciation of the diversity which exists in the animal kingdom, and this volume goes a long way towards dispelling the typical genericism with which young people are often presented the terms of frog, snake, and turtle.

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Poisonous Snakes

By Tony Phelps. 1989. Revised Edition. Blandford Press, London. U.S. distributors: Sterling, New York. 237 pp., illus. Paper U.S. $17.95.

A book on poisonous snakes is hardly essential in the Canadian naturalist's backpack. Of our 25 native species only three were dangerous to human life, all rattlesnakes. These pose no difficulties or confusion in identification: the name itself gives the only field character generally needed. One (the Timber Rattlesnake, last taken in the Niagara Gorge in 1941) is presumably now gone from Canada, the other two are restricted to southern and west central Ontario (the Massasauga, *Sistrurus catenatus*) and arid areas of southern Saskatchewan, Alberta, and British Columbia (two races of the Western Rattlesnake, *Crotalus viridis*: the Prairie Rattlesnake *C. v. viridis*, and the Northern Pacific Rattlesnake, *C. v. oreganus*). Fatalities due to snakebite in Canada are so rare many people outside the range of our few rattlesnakes do not even realize they occur in the country. Even where they occur a bite is usually front page news.

What then of the world-travelling naturalist? *Poisonous Snakes* is *not* a field guide in format nor intent. Beyond the rattlesnakes, many poisonous species are mimicked in colour and pattern by one or more harmless ones, so a comprehensive local guide is a must to distinguish them.

Where this book does find its niche is for general background reading: it presents a broad wordscape with a smattering of photographs, some in colour, of the diversity and distribution of poisonous species and interesting bits of their behaviour and ecology. It is heavily focused on the audience of those who for interest, challenge, or to attract attention to themselves (or all three), keep snakes - an audience perhaps greater than one might realize exists. This adds flavour.

In the world, about one-third of the approximately 3000 species of snakes are "poisonous". About 15% of all species are front-fanged, many of these highly venomous: the cobras and allies, family Elapidae (including the sea snakes as subfamilies, though some authorities raise then to family rank), and the vipers, family Viperidae (including both pit vipers - to which the rattlesnakes belong - and the "pitless" vipers of the old world). Some very toxic members in these families give snakes their traditional fatal image, though even within these groups many species are never, or hardly ever, fatal to humans. Some are so secretive that they are rarely even seen. Over 60% of living snake species are traditionally grouped in one family, the "typical" snakes, family Colubridae. Of these 30% have enlarged fangs toward the back of the mouth and poison of various potencies from a human perspective - though only three are well-documented to have caused human deaths. One small rear-fanged species not regarded as dangerous to humans, though it can quickly subdue lizards, is the Night Snake, *Hypsiglena torquata*, discovered as part of the Canadian fauna in British Columbia only in the last decade.

Poisonous Snakes covers all three families. An Introduction gives glimpses of Anatomy, Senses, Feeding, Locomotion, Skin Shedding, and Periods of Inactivity, all in five pages. Classification and Distribution is 33 pages. The author's obvious discomfort with the theoretical basis of systematics and taxonomy makes it advisable to only skim, or perhaps skip, this section. It is especially poor if one wants enlightenment on philosophic issues, particularly variation and subspecies. Most of the section is a bare list by families of included genus and species

names together with countries and/or continents of occurrence. Some drawings of snake skulls illustrating both familial differences and variation within families as well as maps of family distributions are included. The Rear-fanged Colubrids cover 16 pages, the Elapids 30 and the Vipers 34. The last half of the book contains chapters entitled Habits and Behaviour, Venom and Snakebite, Snakes and Man, Poisonous Snakes in Captivity, and In the Field. Two appendices: Principal Antivenin Scources (world-wide) and Emergency Procedure for dealing with Snakebite (by Dr. A. H. Reid, Liverpool School of Tropical Medicine), a 4-page Glossary of terms, a 2-page Selected Bibliography, and a 12-page Index complete the book.

The author's hands-on experience shines in the chapters of the last half, and these are often both interesting and instructive reading, none-the-less-so for being evangelical in their endeavour to interest the reader in snakes as individual life-forms worth preserving. If you have not thought of snakes this way, this book, focused on the least likeable snakes from a human view, is a good place to start.

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Living Snakes of the World in Color

By John M. Mehrtens. 1987. Sterling, New York. 480 pp., illus. U.S. $50.00; U.S. $70.00 elsewhere.

If snakes are nearly universal subjects of fascination, invoking responses ranging from horror to worship, a book of world snakes in color should be a publisher's dream. These emotions are proven best sellers. Indeed, there is growing evidence from a new stream of books in whole or part dwelling on these legless vertebrates that their pictorial marketability, at least, has been truly discovered.

Living Snakes of the World in Color is a addition to any reference shelf simply because it assaults the eyes with a kaleidoscope of variation in a major but often secretive vertebrate group. It covers only 413 species of the nearly 3000 recognized in the world but those chosen represent 164 genera with 454 subspecies (according to the publisher's own count) included to give a perspective of the variation that can exist within some species. Many South American and Old World species are illustrated along with the standard North American familiars.

The organization is simple. A page of introduction and a page of acknowledgments are followed by 423 pages of group and species accounts arranged in systematic order under three major headings: Primitive Snakes (Boa Constrictors and Anacondas; Specialized Boas; the Pythons; the Acrochordidae); Colubrids – the "Typical Snakes" (the Ratsnakes; Bullsnakes, Pine Snakes, and Gopher Snakes; the Kingsnakes; Indigo Snakes, Cribos, Whipsnakes and Racers; Water Snakes and Their Allies; Other Colubrids; Opisthoglyphous Colubrids – the Rear-fanged Snakes); Venomous Snakes (Venom and Antivenom; Proteroglyphous Snakes – the Elapids; the Sea Snakes – Laticaudinae and Hydrophiinae; Solenoglyphous Snakes – the Viperids; Pit Vipers – the Crotalids; Asian Pit Vipers – Trimeresurus; Neotropical Pit Vipers; Rattlesnakes). The book concludes with a Glossary; Metric Conversion Chart; About the Author; Technical Name Index, by genera; Common Name; and Subject Index. There is no reference list.

The introductory sections are undivided but the species accounts follow a standard formal: English name(s) and scientific binomial or trinomial in a heading with text below labelled: Habitat, Geographic Range, Natural History, Care. The first two are generally one to three lines, and the last almost as short, with a few exceptions. For Natural History the text may run as much as several paragraphs. This includes brief statements on colour and pattern, habitat, food, life history, and habits, as well as occasional taxonomic and systematic comments. Generally, all this text is compressed in a half a page per species as the other half is taken up by at least one large colour photograph, or two or three smaller ones. One strength of the book is that different colour or pattern phases are often shown, either of contrasting subspecies or of distinctive individual variants.

Snake classification is grounded on fine points of skull, hemipenal, and scale variations and the emphasis here largely skips such mentally straining technicalities. There are no keys and no distribution maps. The wealth of photographs do allow a visual sorting that can be confirmed from the dryer technical tomes if a reader wants or is able to follow it that far into secure identifications. Inevitably, many pictures are less sharp and true either from the frustrating difficulty of getting all or any of a cylindrical and elongate animal which coils in varying configurations in focus, or from poor reproduction. That aside, the breadth of the selection is impressive.

The final emphasis on captive care in each account flags this as a pet-keepers', more than a naturalists', book. Confirmation is in the introduction where the selection is stressed to be "those that

are most often seen in public reptile exhibits and private collections, or kept as 'pets'", though the author weakly includes a disclaimer that the captive notes "are included primarily on behalf of snakes already captive, and for individuals whose only source of information is often overly simplified or obsolete literature" and that they are "...not to be construed as encouragement to keep any snake, harmless or venomous...". Unfortunately, many of the unseen legion of private "herpetologist" keepers will relish the book as a glorified glossy equivalent of a department store catalogue, and scan reptile dealers lists to match the pictures on the common excuse that their buying "just one snake" will never endanger a species, or that they intend to "breed it", rarely admitting even to themselves that collectively they must add significantly to the slow but sure decimation of natural populations. The keepers may or may not be sincere. Certainly they are misguided. There are always some dealers to whom the dollar to be made excuses virtually any collection if the demand is there. The self-styled innocent egocentric keeper is the mainstay support of these dealers. Neither are warned of the increasing fines and enforcement at state and provincial levels in North America or elsewhere for possession of many species, although the author himself is described (page 450) as currently a "zoological park animal broker" and therefore must certainly be well-grounded in current legislation. There is a conservation quandry here: unless something is valued it may be allowed to vanish unnoticed and unmourned, if it is valued this itself may lead to its overexploitation and eventual disappearance.

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Proceedings of the International Symposium on King and Tanner Crabs, Anchorage, Alaska, USA, November 28-30, 1989

Edited by T. C. Shirley. 1990. Alaska Sea Grant College Program Report No. 90-04. University of Alaska, Fairbanks. 633 pp., illus. U.S. $14.00..

This is a fat little book containing over 50 papers categorized under the headings: Reproduction, Life History, Feeding and Growth, Mortality, Population Structure and Dynamics, and Stock Assessment and Management. They come from fisheries personnel in Canada (Atlantic and Pacific), the USA, the USSR, Japan, and Argentina. Because King and Tanner crabs are economically important, the emphasis in the papers is on research or data that may prove helpful in managing the crab fishery resource. The book is therefore almost entirely aimed at fisheries biologists. However, it contains a lot of interesting and some controversial findings.

Papers that I found particularly interesting included Conan et al., reviewing and discussing the literature on growth and maturity, and mating, in Atlantic *Chionoecetes opilio*, where recent studies have contradicted well-established assumptions in the literature, and presenting evidence that continues to support terminal moult in majid crabs. Zgurovsky et al. present a logical argument that the management of the crustacean resource depends also on the management of the fish stocks that are their major predator. Carls and O'Clair have a neat little paper demonstrating the effect of cold air exposure on incidentally caught crabs and on their developing larvae. And Seeb et al. show how genetic information can be used to enforce fisheries regulations.

Since most of the manuscripts were submitted as camera-ready, the publication has an uneven appearance. Also, the editorial process is less likely to pick up typos, of which a number were noted though few were major (such as a transposition of postpuberal and prepuberal on page 165). However, all papers are cleanly presented and legible, and this method of publication does mean that results can be circulated with minimal delay. I can highly recommend this *Proceedings* as a small package containing a lot of information at an extraordinarily reasonable price.

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BOTANY

Ferns and Fern Allies of Canada

By William J. Cody and Donald M. Britton. 1989. Publication 1829E, Research Branch, Agriculture Canada, Ottawa. 430 pp., illus. $38.50 in Canada; $46.20 elsewhere.

Ferns are magnificent plants which exhibit extraordinary variation in shape, form, and colour and grow in a remarkable diversity of habitats. These are the plants which have attracted many, myself included, to the study of botany. It is the genetic, taxonomic, and ecological complexity of pteridophytes, however, that holds the interest for many amateur and professional botanists. It is thus

surprising to learn that *Ferns and Fern Allies of Canada* is the first treatment of Canadian pteridophytes since 1884. Accordingly, it is an important work. Happily, it is also a terrific one.

The introductory section comfortably covers the standard explanations of the scope of earlier research and the various areas of information provided in the text. There is also a Cytology and Biosystematics section which deals nicely with the complex and fascinating world of fern cytology, but runs through the topic of biosystematics rather curtly. The cytology section is confused somewhat by the absence of an explanation of what the genome symbols represent. This surely will confuse many non-professional readers.

The authors examine almost 160 pteridophyte taxa, each treated within a hierarchy of simply stated but effective family, generic, and specific keys. Following a genus description that includes notes on world distribution as well as morphological and ecological characteristics, all species are examined in a standardized manner. Synonymy and a moderately detailed technical description are followed by brief cytological, habitat, and distributional discussions. These are consistently well done. An allowance for miscellaneous remarks at the end of each treatment is most appreciated; here the authors provide important information concerning on-going research, conservation status, unusual ecological characteristics, economic significance, and/or cultural applications. One of the few errors noted here is the statement that *Phegopteris hexagonoptera* as the only fern confined in Canada to the Carolinian Zone. It is, in fact, not confined strictly to that area, but *Cystopteris protrusa* is and *it* probably constitutes Canada's only exclusively Carolinian fern.

I would have preferred more discussion of ecological preferences of particular species as this can be very helpful in finding and sorting out complex and/or rare taxa. The book is already large, however, and verbal and financial economy undoubtedly demanded brevity in all areas.

I was particularly pleased to see the treatment of hybrids. Hybridization is a major force in fern speciation and thus it is valuable to see a discussion of the origins of various combinations and how these interrelationships have contributed to diversity. The treatment of holly fern (*Polystichum*) hybrids is greatly assisted by a schematic of the interspecific relationships. It is unfortunate that similar diagrams were not included for other complex groups such as *Dryopteris*, *Asplenium*, and *Cystopteris*.

The very effective line drawings provided for each species are not only visually pleasing but offer important identification assistance. They are only inadequate for *Isoëtes* species. It is impossible to identify several of the Canadian taxa from these single-side views of megaspores, but in that deficiency the book has lots of company.

This treatment follows traditional taxonomic concepts in most cases. The authors, however, usually identify the ambiguous or problematic taxa so the reader can draw his/her own conclusions. I strongly question the treatment of *Botrychium obliquum* as a species distinct from *B. dissectum*, however. It is widely accepted that not only do these taxa constitute one species but they are likely only separable as forms.

Following the fine species treatments are small but clear dot distribution maps for each species discussed. These are so much more descriptive than range delimited by shading or lines. There is a heavy reliance on the larger Ontario herbaria for these range data, however, which may bias the distributional picture somewhat. Only one major error was noted here; the maps for *Azolla caroliniana* and *A. mexicana* are interchanged.

The book was caught up in governmental limbo for a number of years before publication and was actually ready for printing in 1983. Although addenda are added to update research and literature findings, the book has a somewhat dated "feel". In some ways that 1980s perspective may be for the best. Pteridophyte taxonomy and nomenclature are undergoing the greatest changes this century and the next decade will likely see the publication of a great many new species, combinations and nomenclatural changes. Cody and Britton have produced a truly fine summation of the gains in Canadian pteridophyte knowledge over the last century and have set the stage for the next. This delightful and useful book will serve us well until the taxonomic dust settles. Let us hope that we do not have to wait another century for that to occur!

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Field Guide to the Hybrid Ferns of the Northeast

By Frank Thorne and Libby Thorne. 1989. Academy Books, Rutland. 79 pp. illus.

Our understanding of hybridism in ferns is probably unsurpassed by any other large group of plants. Despite this, remarkably few treatments of fern hybrids have been produced. This lovely little book may well be the first comprehensive effort in eastern North America.

It grew from the passion of the late Henry Potter, an avid and skilled Vermont amateur naturalist who carefully collected, photographed and catalogued over 20 different fern hybrids in his home state.

After his death, field associates Frank and Libby Thorne pulled his material together as a tribute to their friend. No doubt, he'd be delighted by their efforts.

The book is directed at the amateur botanist and initiates him/her with an biophysical overview of Vermont before delving into the deep, dark pool of fern jargon. They provide a traditional and very satisfactory introduction to fern morphology, life cycles, the mechanisms of hybridization, collection techniques, and identification. These are clear, straightforward and right on the money. Then they take us, taxon by taxon, through the wonderful diversity of hybrid ferns in Vermont and adjacent areas of New England and Canada.

The authors are due a thousand thanks for rigorously sticking to a standard treatment for each hybrid. Nothing is more aggravating that having to decide upon the affinity of a characteristic when the expression of that feature is described for only one of the options. This excellent treatment begins with the hybrid's parental combination, followed by its binomial (if one exists) and common name. A terrific three column morphological table with descriptions of various macro and micro features then covers half the page. It compares the hybrid (central column) with either of its parent (side columns) in wonderfully lucid terms. Key factors in identifying each hybrid are then listed in point-form, including suggestions of similar taxa which should be considered.

As valuable is the facing page of black-and-white photos. The top left is always an illustration of a full frond of the hybrid, with a detailed section shown at the top right. The bottom left illustrates a full frond of one adult while the bottom right illustrates the same for the other adult. These are where one first goes to identify a hybrid and their high quality of resolution proves up to the task.

The authors exercise great care with this book; it is obviously a labour of love. Accordingly, it is surprising to see the atypically poor quality *Woodsia* illustrations, and even more surprising to see an obvious photo of *Woodsia ilvensis* labelled as *W. glabella*. This species is not even known to hybridize in Vermont. This, happily, is one of the very few gaffs.

Improvements? It would have been helpful, for clarity, to have authorities listed with the scientific names at least once in the text. Similarly, a better indication of the status and distribution of each taxa rather than just "rare" or "common" would have been appreciated. And its appeal and importance would have been enlarged tremendously had all pteridophyte hybrids been treated, not just the "true" ferns. But these are trifling points.

I really love this little book. It is not only a valuable reference source (some 40 taxa are identified and illustrated, after all) but a visually attractive work to browse through. With it one can marvel at the beauty and diversity of fern shapes and patterns. The *Asplenium*s are particularly satisfying in this regard.

This book is a 'must' for every fern enthusiast in eastern North America. Now if someone will just do the southeastern United States...

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ENVIRONMENT

The Risk Assessment of Environmental Hazards

Edited by D. J. Paustenbach. 1989. John Wiley and Sons, New York. 1184 pp. U.S. $125.

Once in a while I find a book I wish I had seen many years earlier and this is one of those books. It would have been so useful some years ago when I first became involved in risk assessment. But I quickly realised that a number of sections were going to be immediately useful to my current work on dioxins. What better recommendation for a book than to say it is valuable to scientists new to the field and has material that is of immediate use to those with experience.

The editor has achieved this by combining a series of case studies, some of which have appeared in the literature before, into a coherent text. There are eight sections titled: Basic Principles, Risk Management and Assessing Water Contaminants, Hazardous Waste Sites, Air Contaminants, Occupational Hazards, Potential Hazards to Consumers, and the Risks to Wildlife.

Each section has a number of chapters (there are a total of 34); each of which is a case study or a discussion paper. The case studies begin with the fundamentals and work through, with examples, to the final assessment. This involves a certain amount of repetition, particularly in the fundamentals, but I found this a benefit rather than a detraction. There are always some differences between scientists in how they handle their information, particularly the assumptions they are forced to make.

Risk assessments follow a basic pattern which, despite the varied nature of the chapters, is easy to discern. First, one needs to establish the compounds of concern. Invariably we are forced to adopt some

assumptions, and these must be clearly identified and justified. The (potential) pathways and transport mechanisms (or their nearest equivalent) should be specified, and the concentrations of the compounds under investigation need to be obtained for those pathways. Estimates for the rate of uptake by target organisms (often humans) and the potential half-life are then identified so that the residual concentrations can be calculated. By comparing the results of this work with known responses by the system to the compounds under scrutiny one can make an assessment of the risk to the organism. There are of course many uncertainties associated with this process and it is essential that these are included in the assessment. If the risk is unacceptably high, as judged against socially accepted criteria, then action is called for to remediate the problem. Again criteria are needed to judge the progress and level of completion of the remediation. Because of our state of knowledge it is common for the researcher to evaluate the weaknesses in the process and, often, suggest areas for further work.

In reality, whether the compound is dioxin, methyl mercury, or radon, the dominant pathway (and there is rarely only one pathway of significance) is by direct inhalation or via a complex food chain, the assessment process contains the above steps. Most chapters select one topic and follow it through this process. In many instances there are examples using real questions and data. Even if the readers' problems are not the same as any in the book they should be able to adapt one or more of the case studies to get a reasonable assessment of the risk they are studying.

No single author discusses the fundamental weaknesses in the process in a general sense. They are, however, incorporated into the detailed examination of each case. For example, two of the typical deficiencies are the data and the extrapolations required. Data availability is often very spartan and the authors show the various ways they overcome this and the limitations of their methods. A frequent need is to extrapolate the dose-response curve from high, measured levels to where the first potential effects occur. Again the authors must explain the assumptions they use and how these affect the judgment of critical values.

This book is an excellent source of information on risk assessment methodology and its practical application in various cases. It is, to some extent, also a source of data or at least temporary substitute data. It is generally well written, being always clear in its message if not always correct in its grammar. I class it as an essential purchase for all those involved or interested in risk assessment.

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Audubon Wildlife Report, 1989-90

Edited by W. J. Chandler. 1989. Academic Press Inc., San Diego. xix + 585 pp., illus. U.S. $39.95.

This book is the fifth Audubon Wildlife Report which focuses on American federal conservation policies and initiatives. In this volume the federal agency which is reviewed is everyone's favourite conservation group, the U.S. Army Corps of Engineers. The Corps is responsible for the management of 4.6 million ha of land and water, and is regulated by the National Environmental Policy Act (1969) and the Clean Water Act (1972), as well as acts on endangered species and wild rivers. The Corps is a classic case where regulation has forced an environmental "bad guy" to become considerably more conservation-oriented during the past 20 years. Rather than the rampant damming and water diversion of the past, the Corps' activities are now subject to EIS and public review. The author does not provide a litany of the environmental consequences of Corps programs but instead concentrates on process and current project management. The major thrust of discussion is the Corps' environmental awareness, and the fact that they are in a position to have a major positive effect on inland water quality over the next decade.

A particularly timely chapter devoted to the discussion of Pacific northwest old-growth forests and the controversy over liquidation of those trees. As a summary of the ecology of that ecosystem and as an examination of the issues, the section is excellent. The point is made that to a certain extent the wrath of loggers over job loss is often ill-founded by blaming conservationists for timber withdrawals. Rather, the industry itself is going through an evolution resulting in 35 percent fewer jobs required to produce the same amount of wood compared to the number of jobs needed a decade ago. New technology may further reduce the work force by another 50 percent over the next half-century.

One of the most interesting and fascinating chapters included in all of the Audubon Reports is entitled "Recent court rulings affecting wildlife". Under the American system the courts have been responsible for many important decisions on natural resource use, which have had national implications. Judgements were a result of suits brought by individuals or groups. Some incredible decisions have been

rendered and several are discussed in the Report. For example, the city of Rancho Palo Verdes (near Los Angeles) built a baseball diamond on the last remaining habitat of a species of butterfly. They successfully defended their action by arguing that the law stated that no "person" shall contravene the Endangered Species Act, and a city is not a "person".

Another timely and interesting chapter discusses the effects of climate change on biodiversity. A cogent conclusion is that consequences of warming will be high extinction rates, reduced capacity for evolution, and period of vast loss of biodiversity. The argument is made for dramatic changes in our lifestyles to reverse the projected negative effects, and that those who argue the status quo on the grounds of insufficient evidence are only contributing to complacency within contemporary society.

Other informative chapters address the problem of by-catch (read: discarded fish for which a fisherman has no quota) which is an issue in commercial fisheries which all governments, including ours, have failed to address; conservation of non-game birds; and restoration of degraded range lands. Position papers are also included for: Monarch Butterfly, Humpback Whale, Hyacinth Macaw, Ocelet, Marbled Murrelet, Swordfish, Roseate Tern, and Golden Eagle. Each of the latter chapters are well-researched, well-written, and present succinct accounts of the problems and management for each species. The book, like its predecessors, is enormously valuable for those interested in conservation of wildlife and ecosystems, as a source of information and possible solutions to problems. I highly recommend all of the Audubon Wildlife Reports.

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Northwoods Wildlife: A Watcher's Guide to Habitats

By Janine Benyus. 1989. Key Porter Books, Toronto. 346 pp., illus. $19.95.

This is a general introductory naturalist's guide to the northern wild areas of the United States (excepting Alaska). It is unfortunate that the term "Northwoods" does not fit as nicely to the Canadian landscape due to the very different, more heavily conifer-dominated component of the Canadian north.

The book starts with several introductory chapters including "What's so Special about the Northwoods?", "What is Habitat?", and "Observation Tips". The Habitat introduction is fair notwithstanding that some of the statements are arguable. The Observation Tips chapter is a good general review of what and how to observe in the out-of-doors.

Following these relatively short, introductory chapters, are the specific habitat chapters. These start with lake habitat and proceed through wetland habitats to mature forest type areas. Within each chapter a number of species are profiled with some general information on those species and tips on what to look for when seeking to observe wildlife.

From a general format perspective, the habitat approach is excellent. The book's material is organized by physical habitat type with each habitat classed according to its dominant vegetation. Unfortunately, these chapters lack detail and a format conducive to acting as a reference source. The book is not a field guide. In all fairness it is an introductory guide to habitats and their associated species and "as you get more involved in habitat study you'll begin to notice even finer distinctions than those we have drawn here."

Individual species are examined in varying detail in each section. How and why particular species were selected for review is unclear. The author fails to point out strongly enough, that many species are found in more than one habitat type and therefore the discovery of an animal in a particular habitat does not automatically classify that habitat as to a particular type. The author does point out that "you may not run across the "pure" needleleaf or "pure" broadleaf forest that are pictured".

Written in an easy pleasant style, the author's choice of vocabulary is an attempt to paint habitat pictures for the reader as well as describe the habitat. Pen and ink illustrations are scattered throughout the text further enhancing the book's appeal and decreasing a textbook appearance. The weekend naturalist may find this book of some interest.

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Nature of Australia: A Portrait of the Island Continent

By John Vandenbeld. 1988. Facts on File, New York. 292 pp., illus., $29.95.

An early European explorer reported that Australia was different: the swans were black not white, the trees lost their bark not their leaves, and summer was in January not July. Here in North America we generally have only a vague notion of how different. The distance and our borealcentricity

contribute to our lack of understanding. *Nature of Australia* places the uniqueness of Australia in perspective.

The first chapter emphasizes our parochial vision of the world, with an expansive view of Australia's place in the world. Entitled, "A separate creation", it includes a concise outline of the history of Australia's isolation from the rest of the world, how the isolation has shaped its natural history, and a map of the world centred on the south pole. The book continues with five chapters emphasizing the marine life around the continent, the eucalypt bush and rainforests, the arid centre, the monsoon influenced Top End, and the influence of man during the past 200 years. In each chapter there is a good balance of history, physical geography, flora, and fauna. There is an informed consideration of the origin of the plants and animals and why they are where they are. The text is concise, easy to read and usually accurate due to extensive consultation with biologists throughout Australia. The few outright mistakes I found were about the relatively poorly represented insects. Ants and termites are no doubt very common in Australia. However the claim that 4000 species of ants represents half of the species of animals is overblown. It neglects the amazing diversity of beetles, flies, and hemipterans in Australia.

This book is based on a television series of the same name produced by the Australian Broadcasting Corporation, in association with the BBC and the Australian Heritage Commission. The visual nature of television is reflected in the outstanding photographs throughout the book. Some of the images of small marsupials, (e.g. planigales, numbats, and bandicoots) and lizards (e.g. *Amphibolurus*) are superb. However my major complaint about this volume also stems from the photographs. The same book was published in Australia by ABC at a comparable price. The only significant difference is the quality of photographic reproduction. The Facts on File edition has adequate photographs, but they are substandard compared to the Australian version.

This book will go a long way to familiarizing North Americans with Australia. It is an excellent introduction to its geological and natural history.

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Sonoran Desert Summer

By John Alcock. 1990. The University of Arizona Press, Tucson. 188 pp., illus. U.S. $19.95.

Summer in the Sonoran desert of Arizona – from the warmth of May, to the searing heat of July, to the violent thunderstorms of August – is the backdrop for this collection of short essays. Summer in the desert conjures up images of heat, unbearable heat. Alcock turns down the heat by exposing the intricacies of desert life to our view.

This book is a series of 38 vignettes about desert biology. It starts with a fallen saguaro and then periodically returns to the saguaro with its rotting flesh, attendant flies and birds through the summer. Interspersed are sketches of the lives of bacteria, plants, insects, lizards, birds, and mammals of the desert. The vignettes emphasize the characteristics that enable the organism to survive and thrive in the desert. The value of a Phainopepla's black plumage and the fur coat of a rock squirrel during the heat of summer are explained. A particularly fascinating sketch asks the question: why do Poor-wills have white eggs? It is interesting because the answer is incompletely known. Alcock offers a partial answer and some cautious speculation that pay attention to both history and adaptation. He encourages readers to open their minds and join in the speculation. Another sketch that challenges the mind is an exercise in economics entitled: "The cost of coyote meat: an update".

The book is aimed at an audience of naturalists. This audience will have no problem understanding the concepts, ideas and information Alcock is trying to communicate. Because of his writing style they will also enjoy themselves in the process. Alcock is a biology professor, specializing in the behaviour of insects and birds. Several of the profiles are based on his research, others are based on research by other academic biologists who study in the Sonoran desert, all reflect Alcock's intimate knowledge of the desert. There is a healthy balance of subject material in the vignettes from vertebrates (gila monsters, zebra-tailed lizards, black-chinned hummingbirds, peccaries), to insects (empress butterflies, saguaro beetles, creosote grasshoppers), to plants (brittlebush, crosote), even to one about bacteria. I enjoyed the emphasis on often overlooked insects, while a botanist will probably detect a bias against plants. Throughout the book observations on clouds, storms, the hills, and human behaviour provide an easy to read commentary that connects the vignettes. Alcock's ability to weave a tale is exemplified by an account of swimming in frigid Altantic waters with Magellanic penguins that doesn't detract from a book about the Sonoran desert.

Sonoran Desert Summer is a worthy sequel to Alcock's first book on the desert, *Sonoran Desert Spring*. Given our preference for cool over hot, Canadian naturalists should eagerly anticipate further sequels about the Sonoran desert during the Arizona winter.

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The Coast of British Columbia

By Bob Herger and Rosemary Neering. 1989. Whitecap Books, Vancouver/Toronto. 148 pp., illus. $39.95.

This is a beautiful coffee table book embodying a large collection of outstanding photos of what is surely one of the most heavily photographed parts of Canada. Herger (the photographer) is particularly good at breaking waves. The book should bring much pleasure to residents and visitors.

The text (by Neering) is a pleasant travelogue of the region, but is inadequately supplied with maps. Only a fraction of the places named could be labelled on the single small scale map forming the frontispiece.

The text would have benefitted, too, from a preliminary vetting by a naturalist, as errors are rather too numerous. For example, the author writes that sandpaper-rough glaciers scraped "smooth, rounded mountains into steep-sided peaks;" that potholes in beach sandstone were ground out by ancient glacial action; that "it is almost impossible for the novice birdwatcher to tell one species of gull from another;" that puffins breed in some of the less-inhabited of the Gulf islands and that eagles nest in spar trees. One of the photos is labelled "Lichens: a unique species." Naturalist readers will be exasperated by these mistakes, which is a pity.

It is hard to tell whether the book will help the conservation cause. Only three of the scenes fall into the category of what we who live on the coast call horror pix, whereas a batch of photos taken at random in the region would contain a high proportion of that genre. Only one photo (a small one) shows a clear-cut forest, and two rather dull ones show some minor consequences of an oil spill at sea. People who buy the book, or who receive it as a gift, should not be lulled into thinking that the glorious scenery in all the other pictures will always be there; rather, they should regard the book as a record of what will be lost if conservationists relax. If that is message it gives, the book may do some good.

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Wild Britain: A Traveler's and Naturalist's Guide

By Douglas Botting. 1988. Prentice Hall, New York. 224 pp., illus. U.S. $13.95.

Douglas Botting has presented to the reader a unique travel book, in that it deals solely with "wild areas" that can be found in Britain.

The book, conveniently broken down into seven geographical sections beginning in the southwestern portion of Britain and heading northward, includes accurate descriptions of the diverse landscapes and a variety of habitats. Within these habitats the focus is on such things as flora, weather, marine life, and wildlife that naturalist may encounter. This information is presented in a concise, easy to follow format, complete with detailed drawings, which make this compact book invaluable as a field guide.

Botting writes with the experience of a world traveler and shows expertise, obtained no doubt from the writing of his other travel books, namely *One Chilly Siberian Morning*, *Wilderness Europe*, and *Rio de Janeiro*. He shows himself to be a versatile writer, having the rare gift of an engaging storyteller. This literary merit is evident as he relates many of his own outdoor experiences in the introduction to each section. His vivid descriptions and acute observations allow the reader to become totally immersed in the text. This feature alone makes the book quite different from standard travel guides.

Botting's expertise further extends into his analysis of the habitat and his descriptions of the various terrain types which he covers thoroughly. The reader is introduced to numerous protected areas, advised on the best time to visit each location, and given important, practical information. I found the listings of activities one can engage in of particular interest. As the book is directed towards *all* outdoor enthusiasts, information on such things as climbing, caving, fishing, and trekking is available.

It is also worth mentioning that considerable emphasis is placed on birding. Current data, migration routes, colonies, and seabird stations are often discussed and the text is further personalized with the inclusion of the author's own observations.

The book's text is enhanced with exceptional colour photographs of the "wild areas" being discussed and the inclusion of area maps and road maps is useful in determining locations and/or accessibility. For the convenience of the reader the book also uses Eagle Symbols to signify the areas with the highest wilderness qualities based on a number of factors such as ruggedness, wildlife interests, remoteness, etc. This allows one to refer to such key areas by merely flipping the pages.

To conclude, Botting, a veteran writer, photographer, and 'wild traveler' has succeeded in putting together a book that reflects extensive research, field study, and general knowledge of the outdoors that will benefit naturalists and travelers alike in their search for interesting locations, diverse landscapes and various habitats for pleasure travelling and/or

study. *Wild Britain* is beautifully presented in all its natural glory and priced very reasonably. It is a book I would highly recommend as a worthwhile addition to any naturalist's library.

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Mountains: A Natural History and Hiking Guide

By Margaret Fuller. 1989. Wiley Nature Editions. John Wiley & Sons, New York. 255 pp., illus. U.S. $12.95.

A single book addressing the natural history of mountains is a massive undertaking considering the incredibly wide range of topics one must cover. The author, however, manages to accomplish this challenging task in seven chapters covering 90 subject areas. Whether expanding on such things as the alpine tundra; water, wind and soil; weather; mountain structure; ecosystems; or plant and animal distribution, each topic is well addressed and quite thoroughly covered.

Margaret Fuller is a veteran hiker (logging over 3000 miles in the last eleven years), inveterate mountain lover, and author of three other hiking guidebooks. She combines her extensive experience and contagious enthusiasm with a great deal of research to bring us this detailed natural history of mountain regions. The aim of this book is to encourage people "to observe mountain geology, weather, plants, animals, and ecology" for themselves. With a greater knowledge and understanding comes a greater appreciation and respect for such areas.

The book is very well-organized with chapter headings broken down into numerous sub-headings (90). This feature aids the reader by assisting in locating specific information or paragraphs with the addition of an eleven page index. The language as a whole is directed to the amateur and not the professional with the exception of Chapter 4, Mountain Building and Plate Tectonics. This specific chapter was difficult to read, extremely textbook like, and the subject matter hard to grasp for the lay reader. As the subject matter is somewhat complex, the problem may be that it could not be adequately addressed in the limited space.

The chapter on backpacking is very informative and the author brings to light the fragility of many habitats while expanding on the effects of altitude and weather, plant and animal hazards, health, safety, equipment, and food. Emphasis is on the importance of proper planning to make all excursions a safe and enjoyable experience. Ms. Fuller then goes on to introduce mountain ranges and peaks of the world. Information is provided on geography, mountain heights, types of terrain, along with a few practical tips. This section is also aided by the addition of 21 reference maps. The purpose is to take the reader on an "armchair trip" of these areas, thereby giving future travellers a better idea of where one would like to backpack.

The appendix is a good source of reference as it lists names and addresses for maps and sourcebooks, environmental education centres, natural history, and mountain adventure trips and sources listing trails for the handicapped around the world. The text is also supported throughout with black-and-white photographs and line drawings.

The book is worthwhile as an all-inclusive, concise introduction to the natural history of mountains. The reader can further pursue subject areas of particular interest with additional reading. The material is well-presented and it is commendable that Ms. Fuller has provided such a wealth of information on such a broad topic in the 255 pages.

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MISCELLANEOUS

George Dawson: the Little Giant

By Joyce Barkhouse. 1989. Natural Heritage/Natural History, Toronto. 140 pp., illus. $12.95.

This is a case of art attempting to imitate life. George Dawson was a giant intellect trapped within a tiny body. Similarly, the book tries to give us a large sense of his achievements in a small text. I don't think it succeeds nearly as well as Dawson did.

Throughout the later years of the 19th century Dawson was ranked amongst the premier natural scientists of North America, despite a spine-crippling childhood illness that left him hump-backed and less than five feet tall. Ignoring his physical challenge he became a brilliant geologist, explorer, and naturalist, and also participated actively in numerous scientific and cultural organizations. That included serving as a President of The Ottawa Field-Naturalists' Club between 1892 and 1895. A productive but demanding life of pioneer wilderness travel

and a single-minded dedication to the scientific investigation of Canada strained an already weakened physique, contributing to his tragically premature death in 1901 at the age of 51.

Barkhouse provides the basic information on Dawson's life and the highlights of his various achievements: his geological surveying of the 49th parallel, his explorations in Yukon Territory (commemorated by the naming of Dawson City in his honour), his discovery of the first Canadian dinosaur remains in the Canadian West. She goes beyond that, however, attempting to paint us a picture of what sort of person he was, of his relationships with his family, with friends, and with associates. To emphasize this she employs fiction, relating first-person discussions as she expects they might have happened. This is offered to us in an amply-spaced, small-paged book with large type and a small number of illustrations.

With such limited text to work with there is not much opportunity to go into the nitty-gritty of Dawson's achievements. It is clear that when a choice had to be made between discussing his achievements or the possible nature of his thoughts at the time, the author opted for consideration of his personality and emotions. As a result, Dawson's vast contributions to pioneer explorations in Canadian earth and life sciences are only superficially treated. For the naturalist reader, this is disappointing and frustrating, for he truly was a giant in the field.

I suspect the author's grasp of natural history knowledge is fairly limited and that she may have been uncomfortable handling such information in detail. This is suggested by her casual (and erroneous) report of Dawson finding nesting Black Ducks in Yukon Territory (1000 miles out of known range), her listing of Caribou and Bighorn Sheep amongst "...great animals easily aroused to ferocity..." and the highly subjective (and questionable) assertion that his "...most interesting discovery..." was dinosaur remains in southern Saskatchewan. She goes on to erroneously report that this site "...has since become one of the richest hunting grounds for dinosaur fossils in the world."

Perhaps another reason why I am left unsatisfied with this book is because it is not at all clear who it is aimed at. I suspect it was written for children and young adults, as a number, if not all, of the author's previous works were. The tone and language suggests so. But if this is so I suspect that the absence of explanations of what all the fuss concerning Dawson's work and discoveries was all about would likely "turn off" a young audience in no time. Such questions as his purpose in being involved with the Bering Fur Commission, the various boundary commissions, and his other challenging investigations are skimmed over. How can the reader appreciate the dedication, intelligence and perserverence of the individual if they don't understand the point of his life's work?

And that's too bad, for George Dawson was a brilliant man and, by all accounts, a prince of a guy too. It should be possible to show both sides of him without trivializing either. An understanding of his achievements as anything more than historical curiosities suffers from the failure of this book to provide such a balance. And as Dawson quite literally gave his life for his studies, I am certain that he would not have enjoyed an attempt to put speculation on his thoughts and discussion of his observations on daily life ahead of the importance of his work.

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Travelers of the Cold: Sled Dogs of the Far North

By Dominique Cellura. Translated from French by Kaye Guerin Mann. 1990. Alaska Northwest Books, Bothell, Washington. 159 pp., illus. U.S. $39.95.

The publisher, Alaska Northwest Books, specializes in Alaskan outdoor books ranging from true-life adventure stories to field guides. These books generally are marketed to the Alaskan tourists and urban armchair adventures. *Travelers of the Cold: Sled Dogs of the Far North* is a coffee table book which falls into the same genre.

The book is profusely illustrated with 70 archival sketches and photographs and 120 contemporary colour photographs taken from 32 collections and photographers. Eighteen of these photos and sketches span two full pages producing lavish 12" x 18" plates. The book is very attractively laid out and is printed on high quality paper. The text is broken into two major sections. The first section, "Polar Flashback", with its 14 subsections encompasses a third of the book. It superficially skims over the northern native's historical use of sled dogs, and the role of sled dogs in polar expeditions and the Alaskan gold rush. The second section, "Of Sleds and Men", which covers the remaining two thirds of the book with 15 subsections, romanticizes the contemporary use of sled dogs and their "mushers" in the Arctic – emphasis is placed on the Alaskan Iditarod race.

The superb illustrations, unfortunately, are marred by errors of omission and commission in the captions. For example, the subsection "Why Sleds",

which discusses primarily Alaskan natives, is illustrated with a series of excellent photos of Greenlandic Inuhuit hunters. The photo captions, however, never indicate where the photos were taken and hence lead the reader to believe that they are of Alaskan Eskimos. Errors in the captions such as calling bearded seal skin rope "caribou hide", or referring to a bearded seal as a "walrus" are irksome. There is also annoying misinformation in the text such as "slush hardened into icebergs", or "crows ... roost on icebergs". The 1100 mile Iditarod race from Anchorage to Nome is promoted as "the greatest race on earth". This sounds like rhetoric from the Nome Chamber of Commerce. In fact, many of the world's greatest "mushers" save their talents and their dogs for two other races: the "Northern American" in Fairbanks and the "Fur Rendezvous" in Anchorage.

This book might be the ideal gift for the casual sled dog fancier but not for the serious "musher" or naturalist.

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NEW TITLES

Zoology

*The American crow and the common raven.** 1991. By Lawrence Kilham. Texas A & M University Press, College Station. 272 pp., illus. Cloth U.S.$29.50; paper U.S.$18.95.

*Bird flight.** 1990. By Robert Burton. Facts on File, New York. 160 pp., illus. U.S.$24.95; $31.95 in Canada.

Dinosaurs, spitfires, and sea dragons. 1991. By Christopher McGowan. Harvard University Press, Cambridge, Massachusetts. 384 pp., illus. U.S.$29.95.

Fish tales. 1990. By Nat Segaloff and Paul Erickson. Sterling, New York. 32 pp., illus. U.S.$12.95.

*Guide to the birds of Madagascar.** 1990. By Olivier Langrand. Yale University Press, New Haven, Connecticut. Illus. U.S.$50.

*Grizzly cub: five years in the life of a bear.** 1990. By Rick McIntyre. Alaska Northwest (GTE Discovery Publications), Bothell, Washington. 102 pp., illus. U.S.$14.95; $18.95 in Canada.

†**Immature insects, volume 2.** 1990. Edited by Fredrick W. Stehr. Kendall/Hunt, Dubuque, Iowa. xvi + 975 pp., illus.

The kestral. 1990. By Andrew Village. Academic Press, New York. 352 pp., illus. U.S.$35.

Man and wildfowl. 1990. By Janet Kear. Academic Press, New York. 280 pp., illus. U.S.$35.

The Manx shearwater. 1990. By Michael Brook. Academic Press, New York. 264 pp. U.S.$32.50.

†**Mule deer country.** 1990. By Valerius Geist. NorthWord Press, Minocqua, Wisconsin. 176 pp., illus. U.S.$39.

Nature's nightlife. 1990. By Robert Burton. Sterling, New York. 160 pp., illus. U.S.$12.95.

†**Owls, caves, and fossils.** 1991. By Peter Andrews. University of Chicago Press, Chicago. viii + 231 pp., illus. U.S.$39.95.

Penguin biology. 1990. Edited by Lloyd S. Davis and John T. Darby. Academic Press, New York. 467 pp. U.S.$79.95.

Red data birds in Britain: action for rare, threatened, and important bird species. 1991. By the Nature Conservancy Council and the Royal Society for the Protection of Birds. Academic Press, New York. c320 pp. U.S.$35.

The ruff: individuality in a gregarious wading bird. 1991. By Johan van Rhijn. Academic Press, New York. c320 pp., illus. cU.S.$39.95.

Sensory abilities of cetaceans: laboratory and field evidence. 1990. Edited by Jeanette A. Thomas and Ronald A. Kastelein. Proceedings of a symposium, Rome, 22 - 29 August 1989. Plenum, New York. c710 pp. U.S.$129.

The status of seabirds in Britain and Ireland. 1991. By Clare Lloyd, Mark Tasker, and Kenneth Partridge. Academic Press, New York. c384 pp., illus. U.S.$38.95.

Botany

Index herbariorum, part I: the herbaria of the world. 1990. Edited by Patricia K. Holmgren, Noel H. Holmgren, and Lisa C. Barnett. New York Botanical Garden, Bronx. U.S.$70 plus handling.

*Mushrooms and truffles of the southwest.** 1990. By Jack S. States. Arizona University Press, Tucson. 233 pp., illus. Cloth U.S.$19.95; paper U.S.$9.95.

A naturalist's guide to trees and forest ecology. 1990. By Laurence C. Walker. Wiley, New York. 304 pp. U.S.$12.95.

Plants: extinction or survival. 1990. By Howard and Margery Facklam. Hillside, Enslow, New Jersey. 96 pp., illus. U.S.$16.95.

Environment

*After the ice age: the return of life to glaciated North America.** 1991. By E.C. Pielou. University of Chicago Press, Chicago. ix + 355 pp., illus. U.S.$24.95.

*__Agroecology.__ 1990. Edited by C. Ronald Carroll, John H. Vandermeer, and Peter M. Rosset. McGraw-Hill, Scarborough. xiv + 641 pp., illus. $130.95.

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Cover: Gray Wolf, photographed in Wood Buffalo National Park. Courtesy of L. N. Carbyn. See article by J.B. Therberge on Ecological classification, status, and management of the Grey Wolf, *Canis lupus*, in Canada pages 459–463.

The Canadian Field-Naturalist

Volume 105, Number 4 October-December 1991

Ecological Classification, Status, and Management of the Gray Wolf, *Canis lupus*, in Canada

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Theberge, John B. 1991. Ecological classification, status, and management of the Gray Wolf, *Canis lupus*, in Canada. Canadian Field-Naturalist 105(4): 459-463.

The wolf, listed as vulnerable internationally, remains in 85% of its former total Canadian range, numbering very roughly 58 500 animals. A classification by ecotype based upon prey-base and parallel geographic- or biome-base is proposed for conservation planning. An annual kill by humans of 7% (1 in 14) was calculated from most recent available statistics. Wolves are protected by legislation or policy from hunting and trapping in only 12 places in Canada, representing 1.2% of wolf range and approximately 1600 wolves, or 2.7% of the Canadian population. Relevant conservation questions are raised.

Key Words: Wolf, *Canis lupus*, status, management, conservation.

In Canada, the most extensive, relatively unexploited Gray Wolf (*Canis lupus*) populations are found in the world. Only the former Soviet Union has more wolves, estimated at 88 000 (Minutes, IUCN Wolf Specialists Group, Trondheim, Norway, 2989), but wolves are heavily persecuted there with kill levels exceeding 33 000 per year between 1979 and 1984 (Bibikov 1988). China ranks third, with wolves in Inner Mongolia (estimated at less than 10 000), as well as in the northeast and northwest, however, wolves are persecuted "wherever found" (B. Zhong-xin 1989. The present status of the wolf in China. Department of Wildlife, North East Forestry University, Harbin, The Peoples Republic of China. Manuscript for IUCN Wolf Specialists Group). In the United States, wolves remain only in Alaska (approximately 6000) and Minnesota (approximately 1200), with small founding populations in Michigan, Wisconsin, Montana, and Washington (totalling approximately 100) (IUCN Wolf Specialists Group Unpublished Table, 1988). The greatest populations otherwise consist of 2000 to 5000 in Yugoslavia, 2000 or less in Iran, Afganistan, India, and Romania, and approximately 1000 in Poland and Spain (IUCN Wolf Specialists Group Unpublished Table, 1988). The wolf is listed officially as "vulnerable" by the IUCN (1988).

In the future of wolves, therefore, Canada must play an important role. Wolf management in Canada, however, which is under provincial and territorial jurisdictions, is not coordinated. Consequently, it is important to maintain up-to-date information on, and to develop a national conservation strategy for the wolf.

Status

Wolves currently inhabit approximately 85% of their former range which once covered all of Canada (Carbyn 1983). They are absent in the maritime provinces, south of the St. Lawrence River in Quebec, in southern Ontario, the prairies, and the lower mainland of British Columbia (Theberge 1977) (Figure 1).

In March 1990, I requested provincial and territorial estimates of wolf populations by letter from directors of wildlife branches or furbearer specialists. The results were: Yukon 4500, Northwest Territories 9500, British Columbia 8100, Alberta 4000, Manitoba 4000, Ontario less than 10 000. Densities as km^2 per wolf, obtained by estimating the area of wolf range in each jurisdiction were: Yukon 106, Northwest Territories 341, British Columbia 109, Alberta 128, Manitoba 109, Ontario (using 9500 wolves for the figure provided of 10 000), 86. Labrador, Quebec and Saskatchewan representatives did not feel confident in providing an estimate.

In order to obtain a general national estimate on wolf numbers, I used the modal density of one wolf per 110 km^2, shown by three jurisdictions, for Labrador and Saskatchewan. For Quebec I used a density of one wolf per 100 km^2, inflating the density over the mode because of higher prey densities in the south, but not using Ontario's even greater density because of Quebec's greater proportion of lower prey density in the north.

The result for Canada is a very rough estimate of approximately 58 500 wolves, for which a confidence interval cannot be calculated. Wolf populations were considered stable in the Yukon and

Ontario, stable and increasing in Quebec, increasing in British Columbia and Labrador, declining in Alberta, and stable and declining in Manitoba. These trends are similar to those reported by Carbyn (1987) except for Alberta and Manitoba, which then were stable.

Classification

Considerable debate has taken place over the taxonomic classification of subspecies of wolves, beginning with Young and Goldman (1944) who mapped 17 subspecies for Canada. Jolicoeur (1959) and Nowak (1983) concluded that the number of North American subspecies should be reduced, while Kolenosky and Standfield (1975) proposed an additional one for Ontario.

A taxonomic basis for subspecies has obvious evolutionary validity, and is important to achieve the goal of preserving genetic variety as described in the World Conservation Strategy (1980). However, a case can be made for conservation to be based upon phenotypic diversity. For example, in wolf recovery efforts it may be inappropriate to introduce wolves that come from prey situations different from those of the introduction site. Certainly, estimating the environmental impact of wolves in areas being assessed for re-introductions, such as Yellowstone National Park, is seriously hampered by not having any populations that experience, and so can demonstrate, relative prey selectivity in that environment. There are no Elk-Bison-deer-Pronghorn wolves in the wild. Similarly, for Big Bend National Park where the Mexican subspecies is being considered for re-introduction, there is no population of deer-peccary wolves in the wild.

Another reason for emphasizing wolf phenotypes in a conservation strategy is the current emphasis on the preservation of complete ecosystems. For example, National Park Policy sets out objectives of protecting representatives of the full range of natural regions in Canada. Wolves, as a ecologically dominant species, must be considered in such park and reserve planning.

Figure 1 depicts a classification based upon wolf ecotypes, providing parallel names for prey-based ecotypes and geographic- or biome-based ecotypes. Figure 1 was developed from range maps of major prey species of wolves using Banfield (1974) and biomes described by Rowe (1972). Wolves normally prey upon the dominant or most vulnerable large mammals in their environment (Mech 1970:171).

The classification acknowledges some regional variation in species availability within each ecotype. For example, the extreme east side of the the Northern Rocky Mountain Wolf range has no caribou, so is predominantly an Elk-deer-Moose system. Also, small Riding Mountain National Park in Manitoba provides for another Elk-deer-Moose system but was too small to map. Ecotype boundaries as mapped represent gradient areas rather than sharp lines because prey-types normally change gradually.

The Northern Rocky Mountain Wolf was so-named to be consistent with the United States Fish and Wildlife Service's current recovery team efforts for the taxonomic subspecies given that common name, even though, considering Canada alone, 'southern rocky mountains' is more appropriate.

The wolf ecotypes with the smallest remaining ranges are the Northern Parkland (Bison) Wolf, the Vancouver Island (Black-tailed Deer) Wolf, and the Hardwood-Boreal Transition (White-tailed Deer-Moose) Wolf. The Bison Wolf depends largely on only Wood Buffalo National Park for its survival (Oosenbrug and Carbyn 1982; Carbyn and Trottier 1987, 1988) (where recent controversy has arisen over possible deliberate Bison extermination). The Black-tailed Deer Wolf still occupies its historic range, having recovered dramatically from very low numbers in the 1960s, but is subject to ongoing assessment by the British Columbia Fish and Wildlife Service for wolf control. The White-tailed Deer-Moose Wolf has been eliminated from half its historic range which once included the mainland maritime provinces and northern New England states, based upon the historic distribution of Moose (Peterson 1978: 17) and wolves (Young and Goldman 1944). Thus, there is reason to consider the conservation of these three wolf ecotypes and their habitats carefully.

Management

The Gray Wolf is listed as a furbearer in all jurisdictions. None provide quotas for trappers. It is listed as a game species in all jurisdictions except Alberta and Labrador. Only in British Columbia is it actually managed, with area-specific bag limits. Wolves are killed to protect livestock in most jurisdictions (Table 1).

Bounties are offered on wolves in some counties and/or townships of Ontario, despite their illegality and further pending legislation to prohibit their use by the Ontario government. In 1989, three municipalities in Quebec voted to place bounties on wolves despite objections of the Quebec Ministry of Recreation, Hunting and Fishing. In Alberta, a privately-funded bounty by the Alberta Fish and Game Association has been used as an incentive for trappers, partially to offset current low fur prices.

In the past six years, wolves have been killed to increase ungulate numbers in British Columbia, the Yukon Territory and Ontario. In 1989, only Ontario practiced this controversial form of wildlife management, killing 20 wolves, 18 of which were in the Algonquin District near the southern edge of the species' range where numbers of White-tailed Deer are currently high (M. Novak, Ministry of Natural

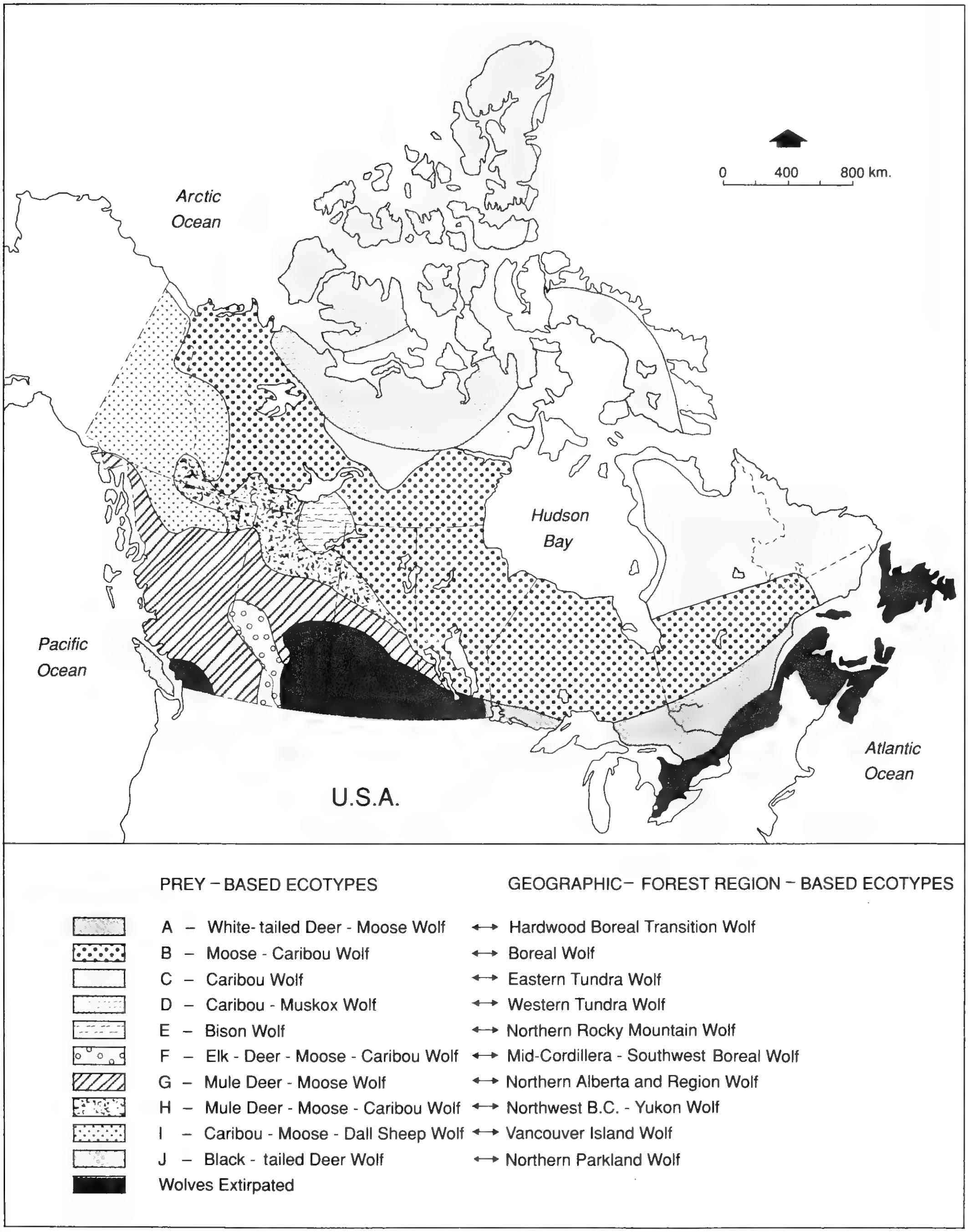

FIGURE 1. Wolf ecotypes in Canada.

TABLE 1. Kill of Wolves in Canada in 1989[a].

Jurisdiction	Trapped	Hunted	Livestock Protection	Ungulate Protection
British Columbia	126	476	150	0
Yukon Territory	100	50	10	0
Alberta	261	200	70	0
Saskatchewan	211	0	24	0
Manitoba	154	25	no data	0
Ontario	506	31	42	20
Quebec	342	no data	0	0
Labrador	7	75	0	0
Northwest Territories	500[b]	500[b]	0	0
Totals	2207	1357	296	20

[a]Data for 1988-1989 except where unavailable and replaced by 1987-1988.
[b]Total trapping and hunting kill is 1000 wolves, but data do not differentiate method.

Resources, Toronto, personal communication). British Columbia is reviewing the biological basis of re-establishing wolf control to increase Black-tailed Deer on Vancouver Island.

The total annual kill of Gray Wolves either in 1989, or 1988 where more recent records were not available, was approximately 3880, or about 7% (one in 14) of the estimated population. This level of killing is somewhat less than a high of 10% (one in ten) estimated for the early 1980s (Theberge 1989). Wolf populations are considered capable of absorbing kills of up to 28%, 33%, or 30-40% (Fuller 1989; Keith 1983; Peterson et al. 1984) respectively. Kills may reach or exceed those thresholds for stability in some areas, such as around some arctic villages where kills are "moderate to heavy" (Hillis 1990), and along the southern edge of wolf ranges in Canada, especially in heavily human populated Ontario and Quebec.

Wolves are formally protected from both hunting and trapping in only 12 locations over 500 km^2 in Canada: La Maurice National Park in Quebec; Algonquin and Lake Superior Provincial Parks in Ontario; Chapleau, and Nipissing Crown Game Preserves in Ontario; Riding Mountain National Park in Manitoba, Prince Albert National Park in Saskatchewan; Banff-Jasper-Yoho-Kootenay National Parks in Alberta; Glacier National Park, Bowron Lakes Provincial Park and the Strathcona Nature Conservancy Area in British Columbia; and the Thelon Game Sanctuary in the Northwest Territories. The size of 500 km^2 was chosen arbitrarily to provide for a minimum viable population size; 540 km^2 Isle Royale provides for the smallest self-perpetuating wolf population known. Left out of this list of protected areas are all northern national parks and other reserves, all of which allow either native subsistence hunting and trapping, or sport hunting, although current activity in some, such as Kluane and Auyuttuq is little to none.

These 12 places where wolves are formally protected, exclusive of park development zones, total 98 121 km^2, or 1.2% of the entire Canadian wolf range. Of this, 5600 km^2, or 57%, is in just one area — the Thelon Game Sanctuary. Extrapolating a high density of one wolf per 40 km^2 for the southern areas, currently the approximate Algonquin density (Theberge, unpublished analysis of current research), and one per 100 km^2 for the Thelon, at the most 1613 wolves, or 2.7% of the Canadian population is free from possible exploitation. These figures ignore trans-boundary territories and dispersing wolves.

Relevant conservation questions that come out of the foregoing review are: (1) whether the small extent of protection described here as existing for the wolf in Canada is adequate given developmental and exploitative pressures and Canada's place internationally; (2) whether more area-specific kill regulations are warranted wherever kill levels approach the danger threshold as explained, and especially for the Hardwood-Boreal Wolf whose range is under considerable pressure, as well as ecotypes on the southern periphery of the species' range; (3) whether existing protected areas need buffer wolf protection zones around them to ensure they accomplish their purposes; (4) what are research priorities, what constitutes ethically acceptable research, and who should fund it?

Obviously, some national cooperative forum and mechanism is needed if these questions are to be addressed. Possibly, the World Wildlife Fund (Canada), with its recently released Large Carnivore Strategy For Canada (Hummel 1990), could help organize such an initiative.

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Status of the Spotted Owl, *Strix occidentalis*, and Barred Owl, *Strix varia,* in Southwestern British Columbia

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Calling surveys were used to assess the relative abundance and distribution of Spotted and Barred owls in southwestern British Columbia from 1985 to 1988. Spotted Owls were located at 14 sites, including pairs at 7 sites and single birds at 7 sites. One Spotted Owl nest was located. Barred Owls were located at 57 sites, including pairs at 14 sites and single birds at 43 sites. The average number of individuals responding per km of survey transect was 0.04 and 0.15 for Spotted and Barred Owls, respectively. The low response rate for Spotted Owls indicates that the species is rare in British Columbia. We estimated the population at not more than 100 pairs. Although the Spotted Owl has probably never been abundant in British Columbia, we hypothesize that the population has declined because of habitat loss and displacement by the Barred Owl.

Key Words: Spotted Owl, *Strix occidentalis*, Barred Owl, *Strix varia*, owls, Strigiformes, British Columbia.

The northern periphery of the range of the Spotted Owl (*Strix occidentalis*) includes the southwestern mainland of British Columbia, from Bute Inlet south to the international border and east to the Skagit River and Spuzzum (Bent 1938; Campbell and Campbell 1984; Howie 1980). Although the Spotted Owl is considered a rare resident within this region, no field surveys have been conducted to determine its status. Its rare status has been assumed from the paucity of historical records (Campbell and Campbell 1984). As of 1985, there were only 28 documented records for British Columbia, including 18 specimen records and 10 instances in which birds were heard or seen (Figure 1). Three of the visual records included adults with young. The most recent record was 1978.

In 1985, the British Columbia Ministry of Environment initiated a field survey to determine the numerical status and distribution of the Spotted Owl in British Columbia, and to collect information on the status of the closely related Barred Owl (*Strix varia*). The Barred Owl has expanded its range into southwestern British Columbia since the early 1940s (Grant 1966).

Study Area and Methods

The study area included mainland British Columbia from the upper Lillooet River south to the international border and east to Spuzzum and the headwaters of the Skagit River (Figure 1). Survey routes were concentrated in older forests (> 100 years old), but also crossed extensive areas of young forest in logged areas and old burns. Surveys were concentrated in, but not restricted to, areas below 1220 m. In many areas, relief was steep, and calls used by surveyors to elicit owl responses were audible at elevations well above 1220 m. No attempt was made to survey the entire study area with equal intensity, but we did try to sample locations scattered throughout the study area (Figure 1). One exception was the Skagit River drainage, within which we attempted a complete survey, thereby obtaining an estimate of the number of owls present.

To determine presence of Spotted Owls, we played tape recordings of their calls in forested areas at night. Spotted Owls usually respond to this technique by vocally challenging the suspected intruder (Forsman 1983). Barred Owls are also responsive to Spotted Owl calls and can thus be inventoried simultaneously, with Spotted Owls. Surveys were conducted at night, between 30 minutes after sunset and 30 minutes before sunrise. While conducting surveys, observers played calls at intervals of 10 seconds to several minutes, listening between calls for a response. Several types of calling routes were used, depending upon the number of observers present and the accessibility of the area to be surveyed. If two observers were present and the area was accessible by road, the observers walked continuous transects along the road, using a vehicle to leapfrog past each other as the transect segments were completed (Forsman 1983). On this type of survey, the observers walked slowly, stopping to call and listen for responses at frequent intervals. When working

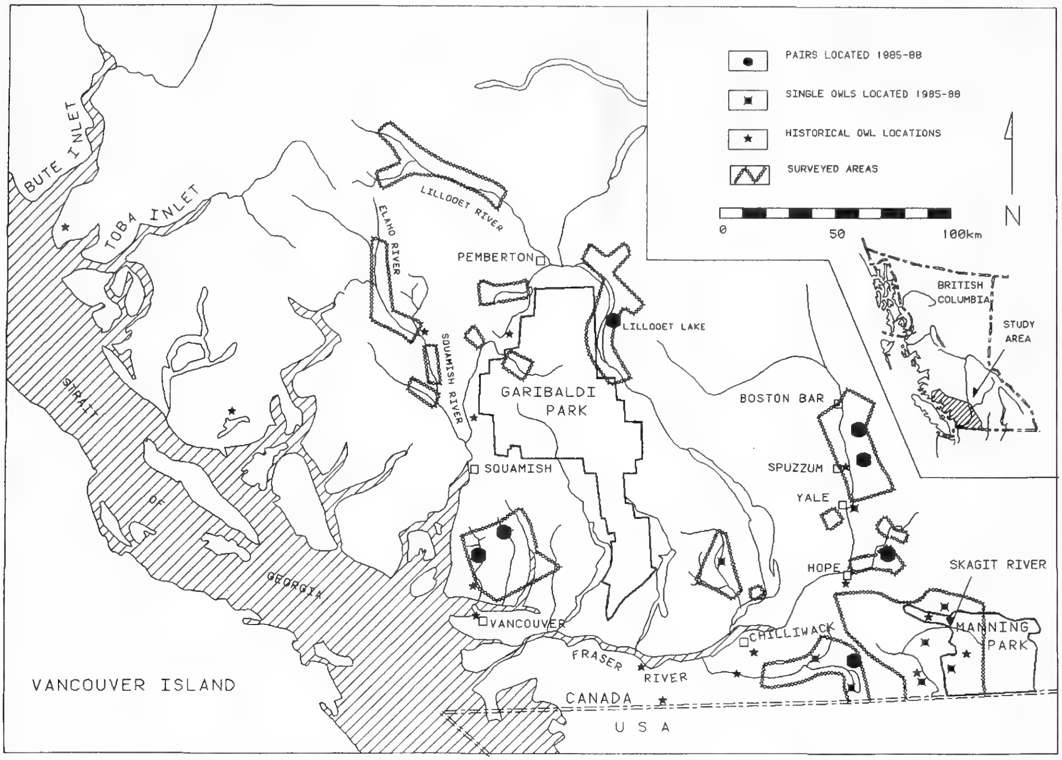

FIGURE 1. Southwest mainland of British Columbia, illustrating locations of Spotted Owls observed or heard before 1985 and found during the 1985-1988 study. Areas surveyed during 1985-1988 are indicated. Historical data from Campbell and Campbell (1984).

alone on roads, observers called from a series of calling stations spaced 0.3-0.5 km apart along the road. Time spent at each calling station was 5-10 minutes. Areas accessible by trail usually were surveyed by walking a continuous transect along the trail. In remote areas with no roads or trails, observers usually hiked in, camped overnight, and then called for as long as four hours from one or more prominent points overlooking the area of interest. Surveys were conducted between 1 March and 1 September. Some routes were surveyed only once. Others were surveyed as many as three times in the same year and in more than one year. From three to eight individuals conducted surveys each year.

The number, species, and sex of all owls that responded were recorded. Sex was determined from differences in pitch of vocalizations (Forsman 1983). The response rate for each species was calculated as the number of owls (excluding juveniles) responding per km of survey transect. Transect length at isolated calling stations in inaccessible areas was counted as 0.8 km per station, which we believe was a conservative estimate of the diameter of the circle that was effectively surveyed around each station. If an area was surveyed more than once, only the first survey was used for calculating response rates. This was done because follow-up surveys at response sites were usually initiated near the point where an owl had been located previously. This has the potential to bias response rates on follow-up surveys. Time spent searching for owls was calculated by excluding time spent travelling to and from survey areas.

Results

Spotted Owls. Between March 1985 and August 1988, we spent 997 hours on 195 nights conducting owl surveys. A total of 420 km of transect was surveyed, not including routes surveyed more than once. Spotted Owls were located at 14 sites, including pairs at 7 sites, single males at 6 sites, and a single bird of undetermined sex at 1 site (Figure 1). Only one pair of owls was located in the northern half of the study area, despite a considerable survey effort (Figure 1). The number of Spotted Owls responding on initial surveys was 18 (4 pairs, 10 singles), producing an overall response rate of 0.04 individuals per linear km of transect. Spotted Owls were located in more than one year at 7 of 10 sites that were surveyed in two or more years. At two sites, owls responded every year for four years. In addition to owls located during surveys, there was one other record of a Spotted Owl during the study; a

female found dead on 25 November 1986 near Yale (Figure 1).

Twelve of the 14 sites where Spotted Owls were located were characterized by forests of Douglas-fir (*Pseudotsuga menziesii*) or Douglas-fir and Western Hemlock (*Tsuga heterophylla*) with variable amounts of Western Redcedar (*Thuja plicata*) and Pacific Silver Fir (*Abies amabilis*). The other two locations were in forests of Western Hemlock, Western Redcedar, and Pacific Silver Fir. Minor components of Lodgepole Pine (*Pinus contorta*), Engelmann Spruce (*Picea engelmannii*), Black Cottonwood (*Populus trichocarpa*), and Red Alder (*Alnus rubra*) were present at some sites. All 14 sites where Spotted Owls responded were characterized by multilayered stands of old-growth forest (dominant overstory trees > 175 years old and > 100 cm dbh) or by a mosaic of old-growth and mature (> 80 years old) forest. Five sites where owls responded were in relatively pristine, unharvested watersheds. The other nine sites were in forest areas that had been fragmented to varying degrees by clearcut logging. All responses were in steep, mountainous terrain, deeply incised by stream drainages. Elevations at response sites ranged from 245 to 1190 m.

Only one pair was determined to be nesting during the survey. The nest was located on 6 June 1986, at 430 m elevation on a west-facing slope overlooking Lillooet Lake. It was located in a mixed stand of old-growth and mature Douglas-fir with scattered Western Redcedar in the understory. The nest was in a cavity in the top of a dead, 114-cm dbh Douglas-fir that had broken off 17 m above ground. One fledged young was found near the nest on 4 July.

Barred Owls. A total of 71 Barred Owls responded at 57 sites during the survey, including responses by pairs at 14 sites and single birds at 43 sites (Figure 2). The number of individuals that responded on initial surveys was 62 (14 pairs, 34 singles), a response rate of 0.15 individuals per linear km of survey transect. This suggested that Barred Owls were nearly four times more common than Spotted Owls. Barred Owls were most common in mixed stands of hardwoods and conifers in the broad riparian corridors bordering major rivers or lakes. At 13 sites, however, they were found in upland stands of old-growth and mature coniferous forest considerably removed from riparian areas. The highest elevation at which Barred Owls were located was 1280 m.

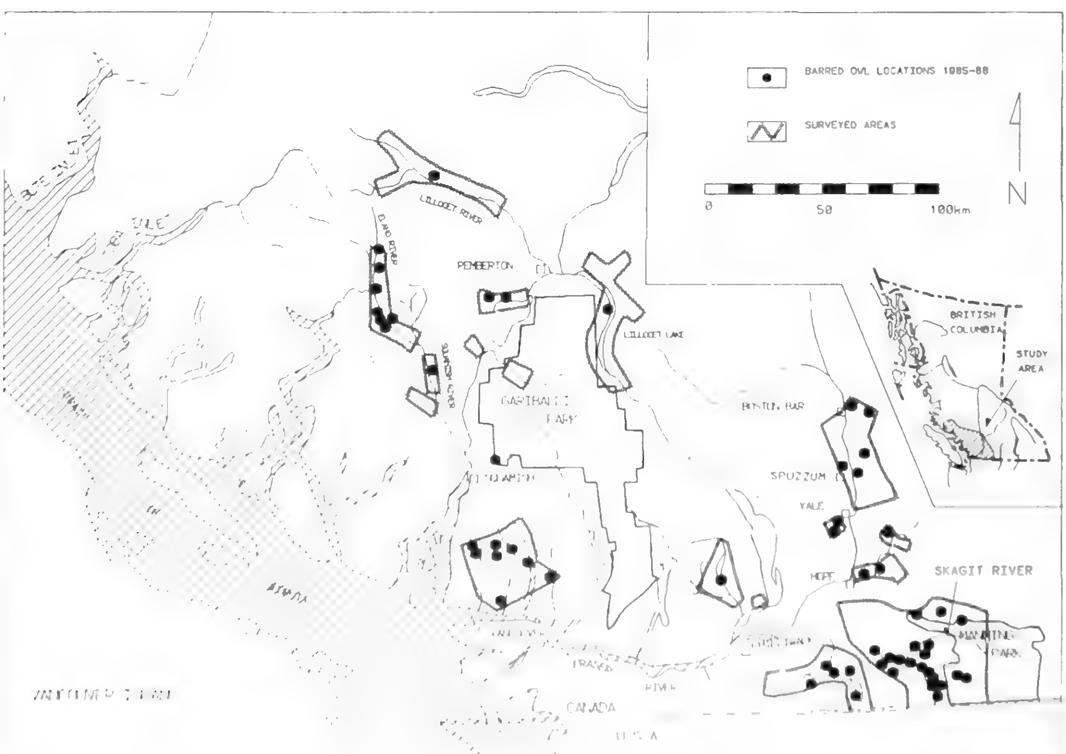

FIGURE 2. Locations of Barred Owls found on the southeast mainland of British Columbia during the 1985-1988 study. Areas surveyed are indicated.

Discussion and Conclusions

Response rates of Spotted Owls in this study were much lower than have been reported in predominantly old-growth forests in Oregon [0.36 pairs/km] (Forsman et al. 1977). Our results are not directly comparable, however, because Forsman et al. (1977) assumed that a pair was present at each site where a response was elicited. If we had summarized our data in this way, our response rate would have been 0.03 pairs/km. In either case, our results indicate that the Spotted Owl is a very uncommon resident in British Columbia. Accurate population estimates are not possible, but we suspect the population does not exceed 100 pairs. North of Squamish and Boston Bar, the species seems to be extremely rare. However, we were unable to survey within the coastal mountains north and west of the Elaho River and south of Bute Inlet (Figure 2). There are two historical records of Spotted Owls in the latter area (Campbell and Campbell 1984), both of which are questionable (R. W. Campbell, personal communication 1990). Additional surveys in that area may produce a few more owls, but we doubt that numbers will be high, as the area represents the extreme northern edge of the range of the Spotted Owl in North America.

Although the Spotted Owl was probably never abundant in British Columbia, we suspect it has declined in numbers during the last century, as the once extensive network of old-growth and mature forests has been reduced by clearcutting, wildfire, and development.

The nest located near Lillooet Lake in 1986 represented the first confirmed nest and only the fourth breeding record of the Spotted Owl in British Columbia (Campbell and Campbell 1984). Single owls were heard near the nest in 1987 and 1988, but their reproductive status was not determined.

Our survey indicates that Barred Owls have successfully colonized a wide range of habitats in British Columbia, including old-growth and mature forest types that are also used by Spotted Owls. We found that Barred Owls responded aggressively when we broadcast Spotted Owl calls, often flying around in the trees overhead, searching for the suspected intruder. We did not broadcast Barred Owl calls to see if Spotted Owls would respond aggressively towards Barred Owls. Of the 14 areas where we found Spotted Owls, 10 were located more than 2 km from the nearest Barred Owl response. At the four sites where Spotted and Barred Owls were heard within 2 km of each other, they were not heard calling in the same area at the same time.

It is not certain when the Barred Owl expanded its range into British Columbia. Grant (1966) suggested that it could have been present for some time before it was first recorded in 1943 (Munro and Cowan 1947). Records from Alberta and Saskatchewan in the early 1900s suggest that Barred Owls may have expanded westward across southern Canada, but it is not clear when or why this expansion began to occur (Grant 1966). What is clear, is that the Barred Owl is now common in southwestern British Columbia, and has also expanded its range to include Oregon, Washington, and northwestern California (Grant 1966; Campbell 1973; Reichard 1974; Taylor and Forsman 1974).

We speculate that the range expansion of the Barred Owl into British Columbia is having a negative impact on the Spotted Owl. This relationship is difficult to assess, though, because many areas in southwestern British Columbia where Barred Owls are most common are areas that were logged in the early 1900s. It is not clear if Spotted Owls are absent from these areas because of the removal of older forests or the presence of Barred Owls, or a combination of both factors.

Of the 14 sites where Spotted Owls responded, only three were in areas protected from logging. It is likely, therefore, that forests at most of the sites where we found Spotted Owls will eventually be harvested. At present, there is no formal plan for protecting habitat for Spotted Owls in the province. However, the British Columbia Ministry of Environment has appointed a Spotted Owl Recovery Team that is currently drafting a recovery plan that will include recommendations for habitat protection.

Acknowledgments

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Sélection de l'habitat et fluctuations récentes des populations d'oiseaux des milieux agricoles du Québec

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Les données de l'Étude des Populations d'Oiseaux Nicheurs (ÉPON) ont servi à caractériser les habitats préférentiels et les fluctuations récentes des populations d'oiseaux champêtres au Québec. Peu d'information nouvelle sur les habitats de nidification a pu être tirée de cette source de données conçue essentiellement pour le suivi des populations d'oiseaux. Par contre, l'étude des tendances démographiques a montré que 10 des 28 espèces examinées ont vu leurs effectifs augmenter significativement entre 1970 et 1986. Trois d'entre elles, le Goéland à bec cerclé, la Tourterelle triste et la Maubèche des champs ont considérablement augmenté leur aire de distribution vers le nord-est, dont au Québec, depuis 20 ans. Les autres espèces à la hausse (en ordre décroissant du degré de signification) sont le Tyran tritri, le Pigeon biset, la Paruline jaune, l'Oriole du Nord, la Corneille d'Amérique, le Merle d'Amérique et le Bruant familier. Six espèces sont en baisse significative. Les plus fortes tendances sont celles du Vacher à tête brune, dont le déclin est notable depuis 1979, et du Bruant vespéral dont la chute précipitée des effectifs est principalement survenue entre 1970 et 1974. Les autres espèces en déclin sont l'Étourneau sansonnet, le Quiscale bronzé, l'Hirondelle des granges et le Bruant des prés. Cinq de ces six espèces sont des omnivores qui se nourrissent au sol dans les champs, ce qui devrait les rendre plus vulnérables aux changements nuisibles des pratiques agricoles (pesticides et instruments aratoires). Par contre, les espèces qui nichent au sol dans les champs ne semblent pas particulièrement affectées alors qu'elles devraient être aussi exposées aux pratiques agricoles nuisibles que les espèces du groupe précédent. Trois des espèces à la baisse (Étourneau sansonnet, Quiscale bronzé, Vacher à tête brune) ont possiblement subi des préjudices attribuables aux programmes visant à réduire le nombre "d'oiseaux noirs" qui hivernent aux États-Unis.

The Breeding Bird Survey (BBS) data have made it possible to characterize habitat preferences and recent fluctuations in populations of farmland birds in Quebec. Little new information on breeding habitats has been derived from this data bank, which is designed primarily to monitor bird populations. However, analysis of the demographic trends has shown that, for 10 of the 28 species studied, significant population increases occurred between 1970 and 1986. Three of them, the Ring-billed Gull, Mourning Dove and Upland Sandpiper, have expanded their range considerably toward the northeast, including areas in Québec, over the past 20 years. The other species whose numbers are on the rise are (in decreasing order of significance) the Eastern Kingbird, Rock Dove, Yellow Warbler, Northern Oriole, Common Crow, American Robin and Chipping Sparrow. Six species have experienced significant decreases in population, with the hardest hit being the Brown-headed Cowbird, which has shown a marked decline since 1979, and the Vesper Sparrow, whose numbers dropped sharply mainly between 1970 and 1974. The other species with declining populations are the Common Starling, Common Grackle, Barn Swallow and Savannah Sparrow. Five of these six species are omnivorous and feed on the ground in fields, a fact which should make them more vulnerable to harm from changes in agricultural practices (pesticides and farm machinery). However, species that nest on the ground in fields do not seem to be particularly affected although their exposure to harmful agricultural techniques should be as great as for the preceding group. Three of the declining species (Common Starling, Common Grackle, Brown-headed Cowbird) may have suffered adverse consequences attributable to programs aimed at reducing the populations of blackbirds that winter in the United States.

Mots-clés: oiseaux champêtres, Québec, sélection de l'habitat, tendances démographiques.

Bien qu'ils aient été générés par l'activité humaine, les paysages agricoles n'en constituent pas moins d'importants habitats pour la faune sauvage. Vu l'étendue considérable des superficies qu'elles occupent – souvent gagnée au détriment des prairies naturelles – les terres agricoles sont devenues des habitats de nidification essentiels pour un grand nombre d'espèces d'oiseaux des milieux ouverts. À cet égard, les changements récents survenus dans nos pratiques culturales pourraient bien avoir eu des conséquences négatives pour plusieurs espèces d'oiseaux champêtres. Selon Statistique Canada (1982, 1987), au Québec, la superficie des terres en pâturage a diminué de façon régulière depuis 1971 alors que, pendant la même période, la superficie des terres en culture a très peu changé. Par ailleurs, la mécanisation des activités dans les champs et l'usage de plus en plus massif de pesticides pour protéger les cultures représentent des menaces sérieuses à la reproduction et au maintien des populations d'oiseaux champêtres.

Considérant ces faits, nous avons cru bon de préciser les habitats de nidification et évaluer l'état des populations d'oiseaux des milieux ruraux du Québec méridional. Pour détecter les tendances démographiques à moyen terme et identifier les espèces en difficulté, nous nous sommes servis des données de l'Étude des Populations des Oiseaux Nicheurs (ÉPON) – mieux connue en anglais sous le nom de *Breeding Bird Survey* (*BBS*). L'ÉPON est un vaste projet de collecte de données coordonné, depuis 1966, par le *U.S. Fish and Wildlife Service* (*USFWS*)

et le Service canadien de la faune (SCF), dont un des buts est précisément de suivre les tendances démographiques des populations d'oiseaux nicheurs d'Amérique du Nord.

Un volet du projet ÉPON, permettant d'acquérir de l'information sur les habitats fréquentés par les oiseaux, a été ajouté aux dénombrements réguliers en 1981 et 1982. Un document du *USFWS* (Robbins et al. 1986) présente une analyse des données colligées entre 1965 et 1979 dans toute l'Amérique du Nord. Un autre plus récent fait le point jusqu'en 1988 (Droege et Sauer 1989). Des rapports annuels concernant les observations faites au Canada sont publiés depuis 1970 (Erskine 1971, 1972, 1973, 1974, 1975, 1976, 1977; Finney et al. 1978, 1980; Freemark et al. 1979; Silieff et Finney 1981; Erskine et al. 1990) tandis que d'autres études présentent les observations canadiennes faites entre 1966 et 1975 (Erskine 1978), de 1966 à 1983 (Collins et Wendt 1989) et de 1966 à 1988 (Erskine et al. 1990). La présente étude constitue la première analyse couvrant spécifiquement le Québec et le milieu agricole en particulier.

Bien que le but principal de ce travail soit d'identifier les espèces en difficulté, nous avons voulu relier les tendances observées aux caractéristiques écologiques et comportementales des espèces concernées afin de suggérer des explications à ces déclins – hypothèses qui pourront être testées dans le cadre d'études futures mieux ciblées.

Région d'étude

Ce travail porte sur les milieux agricoles du Québec méridional. En 1981, la superficie totale des fermes occupait près de 3,8 millions d'hectares – principalement dans le sud-ouest de la province – dont 2,4 millions étaient constitués de sol défriché, le reste comprenant surtout des terres à bois (Statistique Canada 1982). Par rapport à l'ensemble du Canada, le Québec est surtout reconnu pour ses activités d'élevage plutôt que pour l'importance de ses productions végétales. En effet, les grandes cultures n'y occupent qu'un peu plus de 1,7 millions d'hectares, les principales cultures en terme de superficie étant le foin, la luzerne, le maïs-grain et l'avoine. Toujours selon Statistique Canada (1982), nous avons assisté à une importante restructuration de l'agriculture au Québec au cours des trente dernières années. Plusieurs terres agricoles ont changé de vocation ou ont carrément été abandonnées.

L'épandage régulier de pesticides sur les terres en culture constitue un phénomène environnemental relativement nouveau auquel la faune terrestre a dû s'adapter et que nous nous devons d'aborder. En 1982, les agriculteurs du Québec ont utilisé 2,3 millions de kg de matières actives de pesticides (i.e. 450 produits commerciaux représentant 186 matières actives), ce qui représente une augmentation d'environ 8% par rapport à 1978 (Reiss et al. 1984). Les quantités de matières actives vendues en 1982, en fonction de la superficie totale en culture au Québec, correspond à un taux d'application moyen d'environ 1 kg/ha, excluant les huiles (Statistique Canada 1982). Aux États-Unis en 1976, ce taux était supérieur à 2 kg/ha (Eichers et al. 1976 *dans* Reiss et al. 1984). La répartition des ventes de pesticides révèle que les herbicides sont de loin les pesticides les plus utilisés; ils représentaient près de 70% de ventes totales en 1982.

Méthodes

Choix des variables: Une route d'inventaire ÉPON comporte 50 stations équidistantes de 0,8 km. L'observateur passe trois minutes à chaque arrêt et enregistre toutes les espèces vues dans un rayon de 0,4 km et toutes celles entendues, peu importe la distance. Le recensement annuel se déroule pendant la saison de nidification des oiseaux, habituellement au début de juin. Il débute un peu avant l'aurore, les jours où les conditions d'observation sont bonnes (i.e. bonne visibilité, peu de vent, etc.). Les détails de la méthodologie sont présentés dans Robbins et Van Velzen (1970), Erskine (1978) et Robbins et al. (1986).

En 1981 et en 1982, les observateurs ont reçu une fiche spéciale sur laquelle ils devaient décrire les habitats bordant dix stations de leur route d'inventaire. À chaque arrêt ils évaluaient, par un nombre entier de 1 à 10, la superficie relative occupée par chaque type d'habitat, de façon à ce que le total de chaque arrêt soit égal à 10. Au Québec, les stations 11 à 20 ont été décrites le long de 22 routes en 1981 et on a décrit les arrêts 21 à 30 de 21 routes (dont 14 des précédentes) en 1982, pour un total de 43 portions de 10 arrêts provenant de 29 routes différentes.

Certaines routes d'inventaire n'étant pas situées en milieu rural, nous avons choisi d'éliminer les tronçons qui n'étaient pas bordés d'au moins 25% de milieux ouverts (champs de toute nature) de façon à avoir moins de valeurs nulles dans les données d'abondance des oiseaux ruraux, surtout pour les espèces moins communes. En effet, Legendre et Legendre (1979) nous mettent en garde contre le problème du double zéro. Une relation entre deux variables telle une corrélation ou une régression, risque d'être faussée si elles ont trop de zéros en commun. Nous retenons donc 18 portions de 10 arrêts pour notre étude. Seules les données d'habitat et d'abondance des oiseaux provenant de ces portions de route ont été utilisées pour les analyses.

Postulant que la composition des habitats agricoles n'a pas tellement changé (du moins au niveau du paysage; i.e., de la mosaïque des champs agricoles) au cours des vingt dernières années, nous avons mis en relation les données d'habitat avec les

données d'abondance d'oiseaux recueillies au cours de la période 1966-1986 sur les 18 portions de route à l'étude. Les données disponibles auprès du *USFWS* ne contiennent pas les décomptes faits à chaque arrêt, mais plutôt les totaux par segment de dix arrêts (i.e.: 1 à 10, ..., 41 à 50). Chacun de ces segments peut être considéré comme un inventaire et il y a autant d'inventaires qu'il y a eu de visites annuelles à ces parties de route, soit 254 inventaires pour la période à l'étude. Parmi toutes les espèces d'oiseaux recensées dans au moins 20% des 254 inventaires, nous en avons retenu 28 qui, selon D. Cossette, I. Giroux, R. Poulin et collaborateurs (1988. Recueil des principaux pesticides en usage au Québec. Trois volumes. Report technique préparé par SAGE LTÉE pour Environment Canada), fréquentent les habitats agricoles du Québec à la période de reproduction. Le tableau I présente la liste des 28 espèces retenues.

La fiche de terrain pour les habitats ne mentionne que deux types de cultures: le maïs et les petits grains. Comme elles sont peu représentées le long des routes à l'étude (moins du tiers des routes), nous les avons regroupées aux variables "terres labourées" et "autres cultures" pour ne former qu'une grande variable d'habitat que nous avons appelée "cultures" – plus susceptible d'assurer une variation et une représentativité adéquates (mais véhiculant une information plus générale). Les variables "foin", "pâturages" et "pelouse" sont bien représentées et peuvent être prises telles quelles. La variable "champs de type inconnu" a été laissée de côté parce qu'elle nous renseigne peu. Deux variables intéressantes, "prairie naturelle" et "friche", ont dû être abandonnées parce que trop peu représentées et ne pouvant pas être regroupées à d'autres variables de même nature. D'autres habitats, bien que non typiquement agricoles, ont été retenus parce qu'ils font partie du paysage rural et qu'ils sont de nature à attirer certaines espèces associées aux agrosystèmes. Ce sont les étendues d'eau, les buissons et les agglomérations rurales. Certaines espèces communes à la campagne fréquentent ce genre d'habitats et nous voulions faire ressortir leurs préférences à ce niveau. Le tableau 2 présente la description des habitats des 18 portions de route retenues.

Analyses statistiques: Notre analyse des préférences d'habitats repose sur des corrélations non-

TABLEAU 1. Constance et abondance des oiseaux les plus réguliers à la période de reproduction le long des sections de route de dix arrêts où il y a plus de 25% de champs (en ordre décroissant de constance).

Espèce	Nom latin	Code	Constance*	Abondance moyenne**
Étourneau sansonnet	*Sturnus vulgaris*	ES	99.6	34.8
Merle d'Amérique	*Turdus migratorius*	MA	98.8	9.7
Bruant chanteur	*Melospiza melodia*	BC	98.8	8.6
Corneille d'Amérique	*Corvus brachyrhynchos*	CA	98.0	12.0
Quiscale bronzé	*Quiscalus quiscula*	QB	97.6	13.3
Goglu	*Dolichonyx oryzivorus*	GO	91.3	14.4
Carouge à épaulettes	*Agelaius phoeniceus*	CE	90.2	40.9
Moineau domestique	*Passer domesticus*	MD	88.2	17.0
Hirondelle des granges	*Hirundo rustica*	HG	86.2	6.7
Pluvier kildir	*Charadrius vociferus*	PK	86.0	3.8
Bruant des prés	*Passerculus sandwichensis*	BP	84.6	12.4
Chardonneret jaune	*Carduelis tristis*	CJ	83.0	4.2
Hirondelle bicolore	*Tachycineta bicolor*	HB	73.5	3.6
Vacher à tête brune	*Molothrus ater*	VA	71.0	3.0
Sturnelle des prés	*Sturnella magna*	SP	65.4	2.4
Paruline jaune	*Dendroica petechia*	PJ	58.7	1.3
Bruant familier	*Spizella passerina*	BF	58.7	2.2
Tyran tritri	*Tyrannus tyrannus*	TY	55.5	1.3
Pigeon biset	*Columbia livia*	PB	46.1	3.9
Oriole du Nord	*Icterus galbula*	ON	38.6	0.7
Tourterelle triste	*Zenaida macroura*	TT	35.0	0.8
Hirondelle de rivage	*Riparia riparia*	HR	33.1	9.0
Alouette cornue	*Eremophila alpestris*	AC	32.3	1.4
Goéland à bec cerclé	*Larus delawarensis*	GB	31.9	7.8
Maubèche des champs	*Bartramia longicauda*	MC	25.2	0.5
Hirondelle à front blanc	*Hirundo pyrrhonota*	HF	23.6	1.0
Bruant vespéral	*Pooecetes gramineus*	BV	21.3	0.4
Crécerelle d'Amérique	*Falco sparverius*	CR	20.5	0.2

*Constance: (nombre total d'inventaires où l'espèce a été notée/254 inventaires) x100.
**Abondance moyenne: nombre total d'individus observés/254 inventaires.

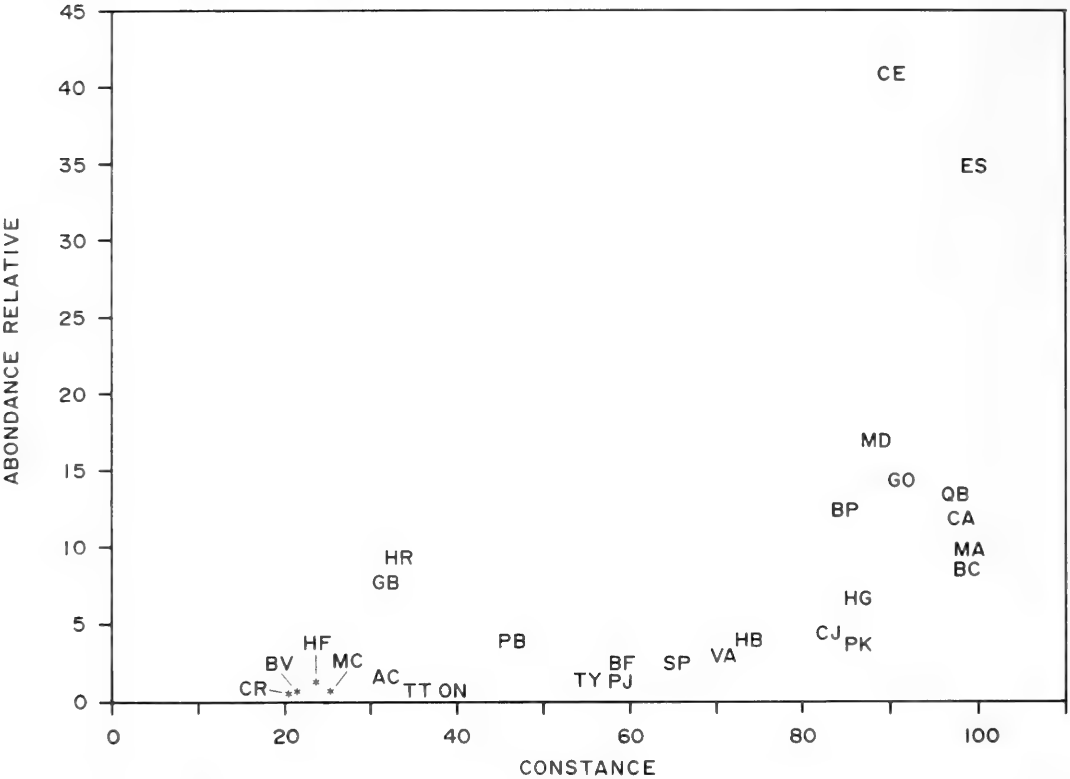

FIGURE 1. Constance et abondance des oiseaux le long des sections de routes (c'est-à-dire 10 arrêts) à caractère agricole au Québec de 1966 à 1986.

paramétriques (r de Spearman avec corrections pour rangs égaux, calculé par la procédure CORR du logiciel SAS) entre chacune des espèces d'oiseaux et chacun des habitats. La corrélation non-paramétrique est suggérée comme substitut à la régression linéaire lorsque des problèmes de non-normalité et de non-linéarité entre les variables sont rencontrés (Sokal et Rohlf 1981). Nous avons préféré utiliser toutes les données d'abondance des oiseaux de la période 1966-1986 plutôt que seulement celles des années où les descriptions d'habitats ont été faites (seulement 18 inventaires) de façon à avoir un plus grand échantillon. Vu que nos segments de route n'ont pas tous été recensés le même nombre de fois, il n'est pas possible de mettre en relation le nombre moyen d'individus d'une espèce par tronçon de route avec les variables d'habitat sans utiliser de pondération (on ne peut pas accorder autant de poids à une moyenne calculée à partir de 5 dénombrements qu'à une autre obtenue à partir de 19 inventaires). Nous avons donc préféré utiliser tous les dénombrements individuels, ce qui élimine la nécessité de pondérer.

Nous avons aussi fait des tests paramétriques (régression multiple, analyse en composantes principales, corrélations canoniques) entre les oiseaux et les habitats dont il était possible de normaliser les données par transformation. Ces techniques plus sophistiquées ont donné des résultats très semblables à ceux de la corrélation non-paramétrique et ne nous ont pas permis de mieux saisir la structure de nos données de sorte que leurs résultats ne seront pas présentés ici.

Nous n'avons pas utilisé exactement les mêmes données pour l'analyse des tendances démographiques, les critères de sélection étant moins limitatifs. En effet, nous pouvons considérer d'autres routes que celles comportant une description des habitats et toutes les données ornithologiques des 50 arrêts d'une route peuvent être utilisées. Les routes ont été retenues en fonction des critères suivants: elles traversent toutes des milieux ouverts (tel que confirmé par les données d'habitat et/ou l'examen de cartes topographiques); elles couvrent toute la période de l'étude et aucune d'elles n'a été plus de trois ans sans être visitée. Il est important de ne retenir que des routes qui ont été visitées sur une base régulière pendant toute la période d'étude car les moyennes annuelles (surtout celles des espèces peu abondantes ou coloniales) peuvent être biaisées quand toutes les routes ne sont pas inventoriées (Droege 1990). On évite aussi de se retrouver, à la fin de la période étudiée, avec un assortiment de

routes différent de celui du début. Par contre, nous n'avons pas rejeté de routes à cause de facteurs climatiques et temporels ou d'un changement d'observateur, comme il est souvent fait (Collins et Wendt 1989; Erskine et al. 1990). Notre étude portant sur des oiseaux de milieux ouverts plus faciles à repérer que les oiseaux forestiers, nous croyons que le "rendement" des observateurs (de toute expertise) doit être relativement fidèle (voir Scherrer 1984, page 48). Nous avons restreint l'analyse à la période 1970-1986 de façon à pouvoir utiliser les données d'un plus grand nombre de routes, soit 16; seulement 8 routes couvrant adéquatement toute la période 1966-1986. Notre effectif statistique consiste donc en 230 inventaires, soit une moyenne de 14,4 recensements par route (sur une possibilité de 17 entre 1970 et 1986).

Les tendances démographiques ont été déterminées à l'aide de corrélations de Spearman calculées à partir des moyennes annuelles pour chaque espèce. Les moyennes d'abondance relative ont aussi été portées sur des graphiques (figures 3 à 7), où le module de régressions de *STATGRAPHICS* a servi à tracer les droites (ou les courbes, selon le cas) d'ajustement des tendances.

Résultats

Communautés d'oiseaux: La constance et l'abondance relative de 28 espèces détectées lors des 254 inventaires retenus pour l'étude sont présentées au tableau 1 et à la figure 1. Deux espèces sont vues partout en grand nombre (35 à 40 individus/10 arrêts). Ce sont le Carouge à épaulettes et l'Étourneau sansonnet. Un groupe d'espèces communes (85% des inventaires) dont font partie le Moineau domestique, le Goglu et l'Hirondelle des granges sont, quant à elles , moins abondantes (5 à 15 individus/10 arrêts). Par ailleurs, deux espèces grégaires, l'Hirondelle de rivage et le Goéland à bec cerclé, sont habituellement vues en groupes, mais de façon plus sporadique que les précédentes (le tiers des inventaires). Les autres espèces sont toutes peu abondantes (< 5 individus/10 arrêts) et certaines, dont la Crécerelle d'Amérique, le Bruant vespéral, l'Hirondelle à front blanc, la Maubèche des champs et l'Alouette cornue, ne sont aperçues qu'à l'occasion (soit le quart des inventaires).

Sélection des habitats: La figure 2 et l'annexe 1 montrent les corrélations obtenues entre les oiseaux et les milieux. Elles sont assez faibles, quelques-unes seulement sont supérieures à 0,50. Une forte proportion des espèces retenues (18 sur 28, soit 64%) est associée aux champs de foin. Les corrélations les plus fortes sont celles du Carouge à épaulettes, du Moineau domestique et de la Maubèche des champs. Douze espèces (43%) paraissent associées aux cultures dont le Pigeon biset, la Sturnelle des prés et la Tourterelle triste alors que trois espèces seulement (11%), la Corneille d'Amérique, le Bruant des prés et le Goglu, montrent une préférence pour les pâturages. Une seule espèce, le Goglu, fréquente régulièrement chacun de ces trois milieux typiquement agricoles. Neuf espèces (32%) montrent une préférence pour les champs en culture ou en foin et

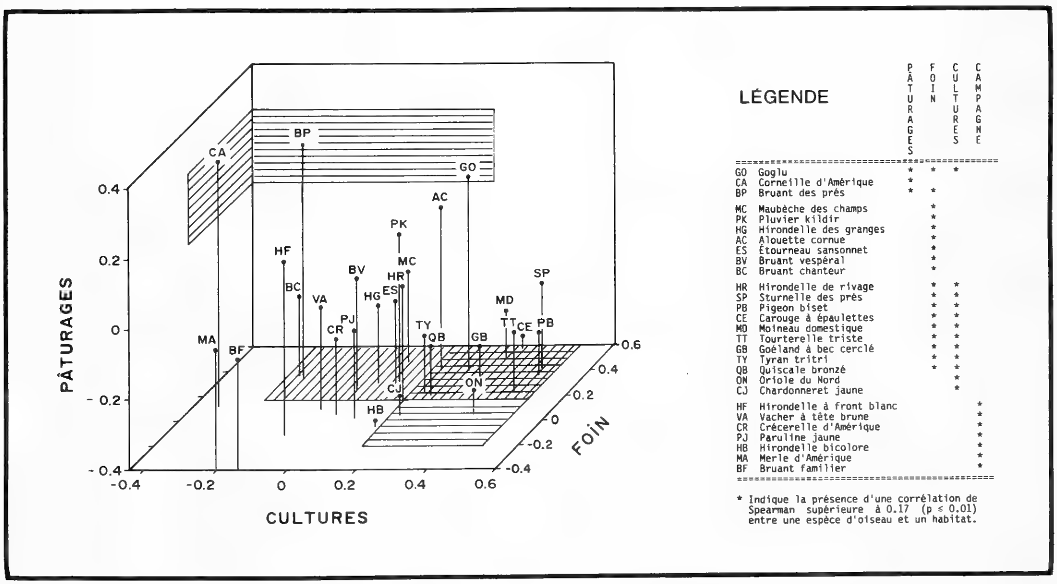

FIGURE 2. Représentation graphique des corrélations de Spearman illustrant les habitats préférentiels des principales espèces d'oiseaux agricoles du Québec.

TABLEAU 2. Description des habitats bordant les routes retenues pour l'étude.

Identification		Localisation			% de la superficie totale occupée par chaque habitat						
numero de la route	arrêts decrits	latitude (°N)	longitude (°O)	localité	agglomérations rurales	étendue d'eau	cultures	pâturages	pelouse	foin	buissons
4	11-20	45.1	73.3	Lacolle	0	0	19	21	1	28	0
4	21-30	45.1	73.3	Lacolle	25	26	17	9	1	14	5
5	11-20	45.7	73.4	Verchères	0	0	16	18	1	63	0
5	21-30	45.7	73.4	Verchères	0	2	13	9	1	36	1
6	11-20	45.8	74.1	St-Jérome	32	1	6	0	2	11	7
7	11-20	45.5	74.2	Hudson	0	0	2	0	3	25	9
11	21-30	45.1	71.9	Coaticook	2	0	37	32	4	0	0
12	21-30	46.4	76.2	Maniwaki	0	1	1	24	3	17	0
19	21-30	46.2	72.4	Nicolet	13	0	16	5	0	16	6
21	11-20	46.7	71.5	St-Antoine	0	0	4	45	1	5	3
23	11-20	46.5	71.0	Ste-Marguerite	0	0	0	24	0	53	9
43	11-20	48.2	79.0	Rouyn	0	0	1	36	2	0	35
43	21-30	48.2	79.0	Rouyn	5	0	0	21	4	0	8
59	11-20	48.6	68.2	Mont-Joli	0	4	0	5	23	42	0
61	11-20	48.7	67.6	Rivière-Matane	0	0	0	17	2	0	0
62	21-30	48.8	67.5	Matane	15	20	7	22	0	0	3
63	11-20	48.3	66.3	Nouvelle	1	0	0	13	0	27	11
69	11-20	48.3	68.1	St-Gabriel-de-Rimouski	0	0	0	4	17	2	3

TABLEAU 3. Tendances démographiques et caractéristiques écologiques des espèces étudiées.

Espèce	Tendances démographiques[1] (1970-1986)	Habitats fréquentés[2]	Régime alimentaire[2]	Site d'alimentation[2]	Façon de s'alimenter[2]	Charactéristiques du nid allure[2]	Charactéristiques du nid emplacement[2]	Région d'hivernage[2]
Crécerelle d'Amérique	-0.04	S,C,F,P	C,I	S,A	R	F	A L	1
Pluvier kildir	-0.37	S,C,F,P,L,E	I	S	G	O	S C	2
Maubèche des champs	0.71**	C,F,P	I	S	G	O	S C	3
Goéland à bec cerclé	0.77**	S,C,F,L,E	I,C	S	G,R	-	- -	1
Pigeon biset	0.69**	S,C,F,P,L	O	S	F	F	- E	1
Tourterelle triste	0.75**	C,F,P	G	S	G	O	A L	1
Tyran tritri	0.77**	C,F,E	I	A	M	O	A L	3
Alouette cornue	0.05	S,C,F,P,L	O	S	G	O	S C	1
Hirondelle bicolore	0.26	P,E	I	A	E	F	A L	2
Hirondelle de rivage	-0.07	P,E	I	A	E	F	- E	3
Hirondelle à front blanc	0.05	P	I	A	E	F	- E	3
Hirondelle des granges	-0.58*	P	I	A	E	F	- E	3
Corneille d'Amérique	0.56*	S,C,F,L	O	S	F	O	A L	1
Merle d'Amérique	0.54*	S,C,F,P,V	O,V	B,S	F,G	O	A L	1
Étourneau sansonnet	-0.54*	S,C,F,P,L,V	O	S	F	F	A L	1
Paruline jaune	0.68**	V	I	B	G	O	T L	3
Bruant familier	0.51*	C,P,V	O	S	F	O	A L	2
Bruant vespéral	-0.76**	F,P	O	S	F	O	S C	2
Bruant des prés	-0.50*	C,F,P	O	S	F	O	S L	2
Bruant chanteur	-0.12	P	O	B	F	O	S L	2
Goglu	0.13	C,F,P	O	S	F	O	S C	3
Carouge à épaulettes	-0.38	S,C,F,P,L,E	O	S	F	O	T L	1
Sturnelle des prés	-0.42	C,F,P	I	S	G	F	S C	2
Quiscale bronzé	-0.64**	S,C,F,L,E	O	S	F	O	A L	1
Vacher à tête brune	-0.81**	S,C,F,P,L	O	S	F	-	- -	1
Oriole du Nord	0.59*	V	O	H	F	O	A L	3
Chardonneret jaune	0.06	C,F,P,V	O	B,S	F	O	T L	2
Moineau domestique	-0.17	C,F,P,L	G	S	G	F	- E	1

Note: Le niveau de signification de la tendance est indiqué de la façon suivante: 0.05 > * > 0.01; 0.01 > **
[1]Mesurées par une corrélation de Spearman
[2]La signification des symboles décrivant les caractéristiques écologiques se trouvent au tableau 4.

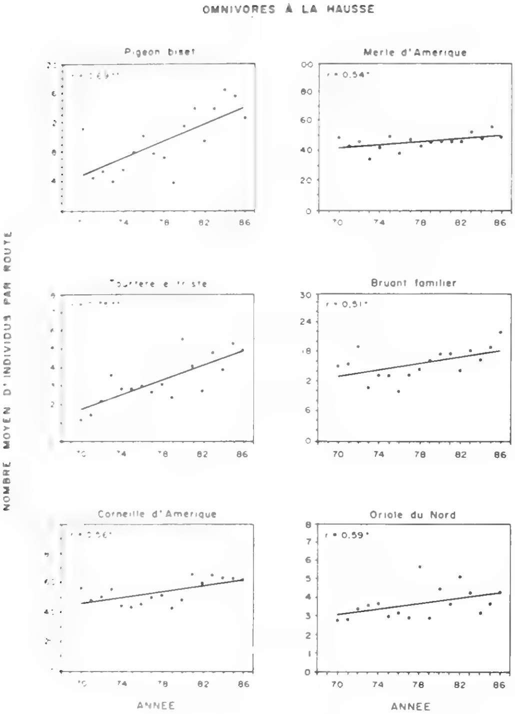

FIGURE 3. Tendances démographiques à la hausse chez quelques espèces d'oiseaux omnivores des milieux agricoles du Québec. Les nombres réfèrent à des abondances le long de sections de routes de dix arrêts.

une seule espèce, le Bruant des prés, se retrouve aussi bien dans les pâturages que dans les champs de foin. Notons également que six espèces (21%) sont plus abondantes près des agglomérations rurales comme, par exemple, l'Hirondelle bicolore, le Bruant familier et le Merle d'Amérique. Quatre espèces (14%) semblent associées à la présence d'eau et quatre autres (14%) affichent une préférence pour la présence de buissons, quoique les corrélations sont très faibles dans ce cas.

L'abondance de plusieurs espèces varie selon la latitude et la longitude de la route d'inventaire (annexe 1). Douze espèces (43%) sont plus abondantes dans le sud de l'aire d'étude – dont la Sturnelle des prés, le Pigeon biset et l'Oriole du Nord – alors que quatre espèces (14%) sont plus communes vers le nord: la Corneille d'Amérique, le Bruant des prés, le Merle d'Amérique et le Bruant familier. Parmi les huit espèces (28%) plus fréquentes à l'est, on retrouve le Quiscale bronzé et la Corneille d'Amérique. Les deux espèces (7%) plus communes à l'ouest sont la Paruline jaune et l'Oriole du Nord. L'examen des corrélations entre les habitats, la latitude et la longitude révèle que les terres en culture sont plus fréquentes le long des routes de la partie sud de l'aire d'étude (annexe 2).

Tendances démographiques: Les tendances démographiques constatées pour les 28 espèces étudiées sont présentées au tableau 3 et aux figures 3 à 7. Dix espèces (36%) ont vu leurs effectifs augmenter significativement entre 1970 et 1986 (figures 3 et 4). Parmi celles-ci se trouvent des espèces telles la Maubèche des champs, le Goéland à bec cerclé et la Tourterelle triste qui ont rapidement augmenté leur aire de distribution vers le nord-est de l'Amérique du Nord au cours de la dernière décennie (Godfrey 1986). La population du Goéland à bec cerclé a littéralement explosé depuis 1976. Mousseau (1984) a bien documenté l'établissement de ce laridé au Québec. Les sept autres espèces à la hausse sont communes et bien établies dans le Québec méridional. Les augmentations des nombres du Pigeon biset et du Merle d'Amérique ont été fortes et régulières, celles du Tyran tritri, de la Corneille d'Amérique, de la Paruline jaune et de l'Oriole du Nord ont fait un saut (*step-trend*) aux alentours de 1980 alors que le Bruant familier a commencé une hausse régulière en 1976.

Six espèces (21%) sont en baisse significative (figure 5). Les plus fortes tendances sont celles du Vacher à tête brune, dont le déclin est notable depuis 1979, et du Bruant vespéral dont les nombres ont chuté entre 1970 et 1974. Une autre forte tendance est celle du Quiscale bronzé dont la baisse a été lente mais régulière au cours de la période étudiée. Alors que la diminution de l'Étourneau sansonnet a été graduelle depuis 1970, les baisses de l'Hirondelle des granges et du Bruant des prés sont plus récentes, commençant en 1978. Deux autres espèces dont les tendances ne sont pas significatives mais dont les effectifs ont diminué constamment depuis 1978 sont

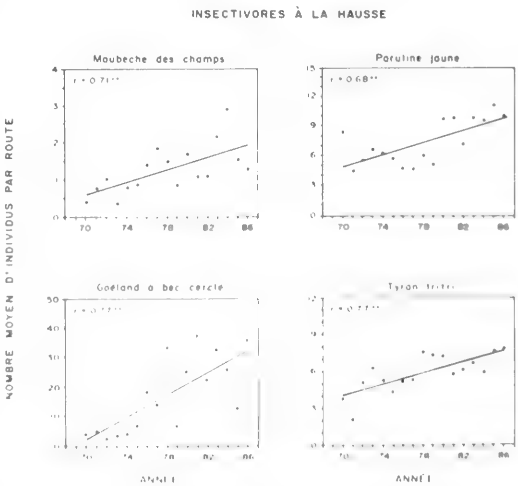

FIGURE 4. Tendances démographiques à la hausse chez quelques espèces d'oiseaux insectivores des milieux agricoles du Québec. Les nombres réfèrent à des abondances le long de sections de routes de dix arrêts.

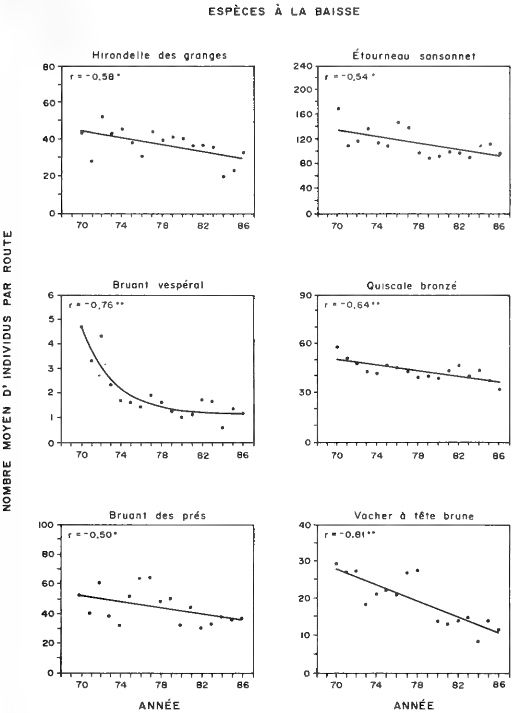

FIGURE 5. Tendances démographiques à la baisse chez quelques espèces d'oiseaux des milieux agricoles du Québec [cinq sont omnivores et une (HG) est insectivore]. Les nombres réfèrent à des abondances le long de sections de routes de dix arrêts.

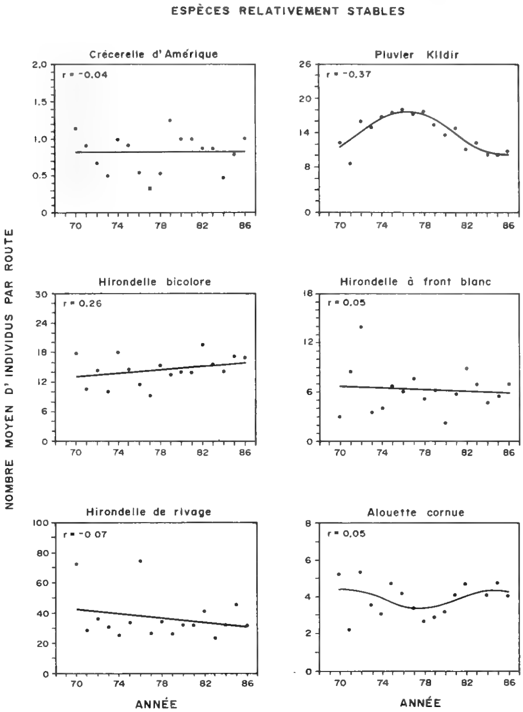

FIGURE 6. Absence de tendances démographiques chez quelques espèces d'oiseaux des milieux agricoles du Québec, 1ère partie [quatre sont insectivores, une (CR) est carnivore et une (AC) est omnivore]. Les nombres réfèrent à des abondances le long de sections de routes de dix arrêts.

le Pluvier kildir et le Carouge à épaulettes. Elles étaient pourtant en progression constante jusqu'en 1977 (figures 6 et 7).

Douze espèces ont maintenu les effectifs de leurs populations à des niveaux relativement stables (figures 6 et 7). Ajoutées aux six espèces à la hausse, elles portent à 18 sur 26 (soit 69%) la proportion des espèces d'oiseaux champêtres du Québec qui sont parvenues à traverser les vingt dernières années sans connaître de difficultés sérieuses sur le plan démographique.

Nous avons tenté de relier ces fluctuations de populations au régime alimentaire des espèces, à la manière dont elles cherchent leur nourriture, aux habitats d'alimentation et de nidification qu'elles fréquentent ainsi qu'à la latitude médiane de leur zone d'hivernage. Les tableaux de contingence qui en ont résulté sont présentés au tableau 4. Un seul s'écarte significativement des valeurs théoriques (que l'on peut calculer à partir des totaux des colonnes et des lignes et vérifier à l'aide d'un test de khi carré), soit celui de la niche alimentaire. On constate que 5 des 6 baisses (83%) concernent des oiseaux omnivores qui s'alimentent au sol en fouillant. Enfin, une autre tendance, bien que non significative, indique que les espèces des pâturages contribuent moins que prévu au groupe des espèces à la hausse.

Discussion

Sélection de l'habitat: Nos résultats à ce chapitre sont plutôt restreints. Les relations faibles et parfois floues que nous avons obtenues quant aux habitats recherchés par les oiseaux tiennent à plusieurs raisons, la principale étant qu'ÉPON a été conçue pour suivre les tendances démographiques des populations d'oiseaux et non pour faire l'étude de leurs habitats préférentiels. Le tracé des routes étant déterminé de façon aléatoire (mais toujours en bordure d'une route avec la complication des effets de bordure que cela entraîne), nous n'avons pas un dispositif expérimental adéquat pour l'étude des relations entre les oiseaux et leur milieu. Les données de certains habitats intéressants ne possèdent pas la variation statistique nécessaire à la mise en évidence des relations recherchées et ces milieux sont présents sur un si petit nombre de routes qu'on n'a d'autre choix que de les éliminer ou de les grouper avec d'autres variables apparentées (également mal représentées) dans une super-variable qui contient alors moins d'information.

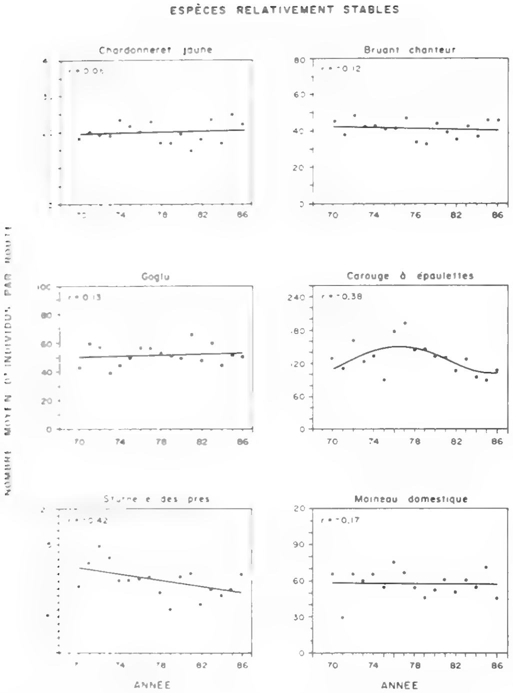

FIGURE 7. Absence de tendances démographiques chez quelques espèces d'oiseaux des milieux agricoles du Québec, 2ème partie [cinq sont omnivores et une (SP) est insectivore]. Les nombres réfèrent à des abondances le long de sections de routes de dix arrêts.

Il convient de rappeler que les participants à ÉPON ne notent pas les habitats dans lesquels sont aperçus les oiseaux, ce qui aurait facilité grandement notre étude des relations oiseaux-habitats. Les données disponibles nous apprennent seulement que l'abondance d'une espèce fluctue généralement en fonction de la superficie d'un habitat donné le long d'une route rurale. Nous ne savons pas si l'oiseau niche dans cet habitat, s'il s'y alimente ou s'il est plutôt attiré par un microhabitat associé à ce type de milieu, mais non recensé par le bénévole.

Enfin, les habitats ne sont pas distribués uniformément dans toute l'aire d'étude. La corrélation de 0,81 qui existe entre les cultures et la latitude de la route indique que les cultures se retrouvent principalement dans le sud de l'aire d'étude. Lorsqu'une espèce est associée à la fois aux cultures et au sud, on ne sait pas lequel des deux effets prédomine. Nous avons donc examiné les données relatives à ces espèces en ne retenant que les sept routes situées au sud du 45° parallèle. Des douze espèces qui, au premier abord, semblaient reliées aux cultures, seulement deux y sont demeurées significativement associées: le Moineau domestique et l'Hirondelle de rivage. Des corrélations partielles effectuées par la suite avec l'ensemble des données ont fourni des résultats semblables, montrant que la présence de cultures influence l'abondance de bien peu d'espèces d'oiseaux.

Tendances démographiques: Les tendances démographiques que nous avons mises à jour ressemblent à celles détectées par Erskine et al. (1990) pour l'ensemble de la région Grands Lacs-Saint-Laurent. Ils ont cependant trouvé que les effectifs de l'Hirondelle des granges et de la Corneille d'Amérique étaient stables alors que nous avons constaté qu'ils étaient, respectivement, en baisse et en hausse significatives au Québec. Ils ont aussi observé une légère baisse chez l'Oriole du Nord alors que cette espèce semble clairement en hausse au Québec. Pour ce qui est des autres espèces, les tendances démographiques rapportées par les deux études concordent très bien, en dépit d'approches statistiques, de régions géographiques et de milieux écologiques en bonne partie différents. Cela pourrait vouloir dire que les fluctuations de populations d'oiseaux champêtres que nous avons détectées en milieu rural au Québec ne sont peut-être que le reflet de changements démographiques plus profonds affectant plusieurs populations d'oiseaux des milieux ouverts du nord-est de l'Amérique du Nord – ce que suggèrent d'ailleurs les résultats de l'étude de Droege et Sauer (1989).

Les oiseaux omnivores qui se nourrissent au sol en fouillant fournissent cinq des six baisses de populations que nous avons décelées (Tableau 4). On conçoit facilement que des espèces qui se nourrissent au sol dans les champs puissent être plus affectées par des changements nuisibles dans les pratiques agricoles, comme l'utilisation de pesticides et d'instruments aratoires. Cependant, nous ne comprenons pas pourquoi les espèces généralistes (omnivores) semblent plus affectées que les espèces spécialistes qui, elles, glanent des graines ou des insectes au sol ou dans la végétation courte. Il est par ailleurs un peu surprenant que les espèces qui nichent au sol dans les champs – et qui risquent davantage d'être affectées par les pratiques agricoles nuisibles décrites plus haut – ne se portent pas plus mal que les autres (Tableau 3). La faible proportion d'espèces à la hausse chez les oiseaux des pâturages pourrait être attribuable à la diminution régulière, depuis 1971, de la superficie des terres en pâturage au Québec. Les baisses observées chez les "oiseaux noirs" (Étourneau sansonnet, Quiscale bronzé, Vacher à tête brune) nous portent à croire que les programmes visant à réduire le nombre de ces oiseaux qui hivernent aux États-Unis sont probablement efficaces pour le contrôle de leurs populations

TABLEAU 4. Relations entre les tendances démographiques constatées et certaines caractéristiques écologiques des espèces étudiées.[1]

	Nombre d'espèces				
	à la baisse	stables	à la hausse	total	khi carré
Habitats fréquentés					
C: Cultures	4	8	8+	20	5.97 (ns)
E: Eau à proximité	1	4	2	7	
F: Fourrage	5	8	7	20	
L: Labours	3	4	3	10	
P: Pâturage	5	12	5--	22	
S: Semis	3	4	4	11	
V: Verger	1	1	4+	6	
	22	41	33	96	
Régime alimentaire[2]					
C: Carnivores	0	1	1	2	5.47 (ns)
G: Granivores	0	1	1	2	
I: Insectivores	1-	6	4	11	
O: Omnivores	5++	5	5	15	
V: Vermivores	0	0	1	1	
	6	13	12	31	
Site d'alimentation[3]					
A: Air	1	4	1-	6	4.53 (ns)
B: Bas de cime/buissons	0	2	2	4	
H: Haut de cime	0	0	1	1	
S: Sol	5+	8	7	20	
	6	14	11	31	
Façon de s'alimenter[3,4]					
E: Engoufreurs	1	3	0-	4	9.51 (ns)
F: Fouilleurs	5++	4	5	14	
G: Glaneurs	0-	4	5+	9	
M: Moucheronneurs	0	0	1	1	
R: Raideurs	0	1	1	2	
	6	12	12	30	
Niche alimentaire[3]					
Omnivores, Sol, Fouilleurs	5+++	3	5	11	8.26 *
Autres	1---	11	10+	22	
	6	14	13	33	
Allure du nid[4]					
F: Fermé	2	6+	1--	9	3.52 (ns)
O: Ouvert	3	6-	8++	17	
	5	12	9	26	
Emplacement du nid[5,6]					
Au sol dans les champs (S C)	1	4+	1	6	1.35 (ns)
Ailleurs	5	8-	7	20	
	6	12	8	26	

suite à la page suivante

TABLEAU 4. (suite)

	Nombre d'espèces[2]				
	à la baisse	stables	à la hausse	total	khi carré
Région d'hivernage[7,8]					
1: au nord du 35e parallèle N	3	4	5	12	3.23 (ns)
2: entre 20e et 35e parallèle N	2	5	1-	8	
3: au sud du 20e parallèle N	1	3	4+	8	
	6	12	10	28	

[1]Le niveau de signification est indiqué de la façon suivante: 0.05 > * > 0.01; ; ns: non significatif.
Dans les tableaux de contingence, la différence entre les valeurs observées et les valeurs théoriques est indiqué de la façon suivante:
1 < + < 2; 2 < ++ < 3; 3 < +++; 1 > - > -2; -2 > -- > -3; -3 > ---

[2]Une espèce fréquentant plus d'un habitat ou appartenant à plus d'une catégorie est comptée une fois dans chaque habitat et chaque catégorie.

[3]Selon de Graaf et al. (1985)

[4]*Façon de s'alimenter*

E	engroufeur	(screener):	attrape ses proies en volant le bec grand ouvert
F	fouilleur	(forager):	attrape presque toutes les catégories de proies rencontrées
G	glaneur	(gleaner):	sélectionne une proie particulière
M	moucheronneur	(sallier):	guette sa proie (insecte) à partir d'un perchoir, la poursuit et l'attrape en vol
R	raideur	(hawker):	poursuie sa proie en vol et l'attrape dans les airs ou au sol

[5]Selon Harrison (1984)

[6]*Emplacement du nid*

A:	dans les airs	C:	dans les champs
S:	au sol	E:	à l'extérieur des champs
T:	dans les taillis	L:	en lisière des champs

[7]Selon National Geographic Society (1983)
[8]Selon **Diamond, A. W.** 1986. An evaluation of the vulnerability of Canadian migratory birds to changes in neotropical forest habitats. Canadian Wildlife Service, unpublished report, 93 pages.

continentales. Le Carouge à épaulettes rejoindra probablement aussi ce clan dans quelques années si sa tendance à la baisse se maintient. On voit donc que les baisses observées ne peuvent pas être attribuées à une cause unique, mais qu'il y aurait plusieurs facteurs en jeu. Dans l'ensemble, la situation des oiseaux des milieux agricoles est moins dramatique qu'on aurait pu le croire. Nous avons trouvé presque deux fois plus d'espèces à la hausse que d'espèces à la baisse (10 contre 6) alors qu'une douzaine d'autres espèces maintiennent leurs effectifs. Selon Erskine et al. (1990), ce pourrait être un signe que les espèces de l'Est commencent à se remettre des effets néfastes du DDT.

Ce travail a permis d'identifier des espèces des milieux agricoles québécois dont les effectifs sont clairement à la baisse. La base de données que nous avons utilisée provient d'une étude de type extensif se prêtant mal aux tests d'hypothèses. Maintenant que nous connaissons les cas problemes, il y aurait lieu de mettre sur pied des études spécifiques de type intensif qui nous permettraient — à l'aide de la statistique inferentielle — d'identifier clairement les causes de ces declins de populations. Cette connaissance est absolument requise si nous voulons corriger la situation et donner ainsi la chance a ces espèces de rétablir leurs effectifs dans les milieux agricoles du Québec en particulier et du nord-est de l'Amérique du Nord en général.

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ANNEXE 1. Habitats et régions fréquentés par les espèces à l'étude.

Espèce	1[er] habitat préféré		2[e] habitat préféré		latitude		longitude	
Crécrelle d'Amérique	—		—		—		—	
Pluvier kildir	foin	(r=0.37)*	—		—		Est	(-0.23)
Maubèche des champs	foin	(0.46)	—		—		—	
Goéland à bec cerclé	étendue d'eau	(0.51)	foin	(0.35)	Sud	(-0.29)	—	
Pigeon biset	cultures	(0.45)	foin	(0.36)	Sud	(-0.51)	—	
Tourterelle triste	cultures	(0.43)	foin	(0.21)	Sud	(-0.46)	—	
Tyran tritri	foin	(0.23)	cultures	(0.17)	Sud	(-0.28)	—	
Alouette cornue	foin	(0.40)	—		—		—	
Hirondelle bicolore	aggl. rurales	(0.44)	étendue d'eau	(0.39)	—		—	
Hirondelle de rivage	cultures	(0.17)	foin	(0.17)	—		—	
Hirondelle à front blanc	buissons	(0.20)	—		—		—	
Hirondelle des granges	foin	(0.29)	—		—		Est	(-0.25)
Corneille d'Amérique	pâturage	(0.31)	—		Nord	(0.46)	Est	(-0.40)
Merle d'Amérique	aggl. rurales	(0.29)	buissons	(0.19)	Nord	(0.20)	Est	(-0.17)
Étourneau sansonnet	foin	(0.30)	—		—		—	
Paruline jaune	buissons	(0.18)	—		Sud	(-0.31)	Ouest	(0.30)
Bruant familier	aggl. rurales	(0.31)	pelouse	(0.28)	Nord	(0.18)	—	
Bruant vespéral	foin	(0.24)	—		—		Est	(-0.23)
Bruant des prés	foin	(0.33)	pâturage	(0.30)	Nord	(0.29)	Est	(-0.23)
Bruant chanteur	foin	(0.35)	—		—		—	
Goglu	foin	(0.40)	cultures	(0.23)	Sud	(-0.18)	—	
Carouge à épaulettes	foin	(0.59)	cultures	(0.31)	Sud	(-0.39)	—	
Sturnelle des prés	cultures	(0.43)	foin	(0.42)	Sud	(-0.51)	—	
Quiscale bronzé	étendue d'eau	(0.29)	aggl. rurales	(0.23)	Sud	(-0.20)	Est	(-0.45)
Vacher à tête brune	buissons	(0.20)	—		—		—	
Oriole du Nord	cultures	(0.39)	aggl. rurales	(0.21)	Sud	(-0.51)	Ouest	(0.25)
Chardonneret jaune	étendue d'eau	(0.39)	aggl. rurales	(0.23)	Sud	(-0.28)	—	
Moineau domestique	foin	(0.51)	cultures	(0.31)	Sud	(-0.32)	Est	(-0.27)

* Note: Seules les relations inférieures au seuil de probabilité statistique de 0.01 (r=0.17) sont présentées.

ANNEXE 2. Corrélations entre les habitats et la localisation géographique.

	champs	foin	pâturage	culture	eau	aggl. rurales	longitude	latitude
latitude	-0.18	-0.32	0.26	-0.82*	-0.13	-0.14	-0.22	1.00
longitude	-0.26	-0.13	-0.10	0.00	0.00	0.06	1.00	
agglomération	-0.68*	-0.45	-0.41	0.27	0.39	1.00		
eau	-0.13	0.05	-0.38	0.13	1.00			
cultures	0.14	0.10	-0.12	1.00				
pâturage	0.32	-0.24	1.00					
foin	0.64*	1.00						
champs	1.00							

*Note: Le niveau de signification est indiqué de la façon suivante: * ≤ 0.01

Macrophyte and Associated Mollusc Communities in a Meteor Crater Lake on the Precambrian Shield in Manitoba

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Submerged macrophyte and associated mollusc communities were investigated in West Hawk Lake, a cold deep meteor crater lake on the Precambrian Shield. Despite good light penetration, macrophytes grew no deeper than 8.5 m, and temperature was probably a major limiting factor. The nine macrophyte taxa showed low biomass and marked vertical zonation, with *Chara globularis* dominating the communities in the lower half of the macrophyte zone. Macrophyte species richness decreased with increasing depth. Ten gastropod species were associated at low densities with the macrophytes. *Valvata sincera* was significantly more abundant at depths of more than 5 m.

Key Words: West Hawk Lake, meteor crater lake, freshwater molluscs, macrophytes, light, temperature.

Submerged macrophyte communities contribute significantly towards the productivity of many lake ecosystems, particularly on the Precambrian Shield, where algal populations are often low and dissolved nutrients are scarce (e.g., Stockner and Armstrong 1971). Macrophyte productivity in any given lake depends on a number of factors: the availability of loose bottom substrate in which rooting can occur, light intensity, chemical parameters such as pH, nitrogen and phosphorus concentrations, and temperature. The maximum depth to which macrophytes penetrate may be limited by light or temperature (Dale 1986). In lakes where light penetration is high, angiosperms nonetheless do not normally grow at depths of more than 10 m (Hutchinson 1975) and appear to be restricted to the zone above the thermocline (Sheldon and Boylen 1977). Where extensive circulation allows for warming of deeper layers and oxygenation of sediments, angiosperms may grow at exceptional depths (Pip and Simmons 1986).

The diversity, density and zonation of macrophyte communities in turn influences the distribution of associated invertebrates. Comparatively few data exist on zonation patterns of littoral communities in various types of Shield lakes, despite the need for such information in the face of the increasing pressure which these lakes sustain from recreational development, acid precipitation, and other incursions, which have already contributed to the disappearance of species from some lakes in Ontario (Shaw and Mackie 1989).

Pip and Simmons (1986) reported diverse vascular plant communities from depths of 14 m in Shoal Lake, on the Manitoba-Ontario boundary. West Hawk Lake is a deep meteor crater lake that is located only 11 km to the northwest of Shoal Lake. On average, the water in West Hawk Lake supports lower algal populations than are found in Shoal Lake (Hughes 1983; Pip 1988), and light penetration is greater, largely attributable to the shorter period of warmer water temperatures in West Hawk Lake in the summer, as well as to reduced dissolved organic matter content. It was therefore of interest to examine the depth to which macrophyte communities penetrate in West Hawk Lake, as well as their composition and productivity along a depth transect. This lake has sustained extensive cottage development and recreational use, and is a training center for SCUBA divers. These pressures have resulted in visible pollution, and while many residents feel that the lake is deteriorating, baseline data on the organisms that inhabit the lake are lacking and thus quantitative comparisons that might indicate any changes cannot be made.

Study Area

West Hawk Lake (49°46' N, 95°11' W) occupies the basin of an ancient meteor crater on the edge of the Precambrian Shield in southeastern Manitoba. It has a maximum depth of 111 m, in addition to approximately 100 m of sand and silt sediments and is the deepest lake in Manitoba. The lake (elevation 341 m above sea level) is roughly circular, with a surface area of the water of 1474 ha, and near the edge the bottom slopes rapidly (Short 1970). At Miller Beach, on the southwest shore of the lake, where sampling was conducted, the grade averaged 140 m/km through the depth range of 0 to 20 m.

The surface water is low in total dissolved solids, varying from 15 to 77 mg/l, although mostly values are < 40; total alkalinity ranges from 12 to 25 mg/l $CaCO_3$, and pH from 7.8-8.1 (Pip, unpublished data). Due to considerable cottage development on the shores of the lake and variable influxes of nutrients, algal populations show year-to-year fluctuation. In some years values of chlorophyll a in excess of 6 μg/l have been observed, and the lake is considered to be moderately enriched (Hughes 1983). Macrophyte communities are sparse and patchy, and only one species (*Potamogeton amplifolius*) achieves

heights of more than 0.5 m. Fish species include Brown Trout, Burbot, Lake Trout, Perch, Pike, Rainbow Trout, Smallmouth Bass, Sucker, Tullibee, Walleye and Whitefish.

Materials and Methods

Sampling was conducted in 1989 at Miller Beach on 24 May, 15 June, 14 July, 18 August, 10 September, 15 November, and 12 December. With the aid of SCUBA, macrophytes were harvested from two 0.5 X 0.5 m quadrats placed randomly in macrophyte patches at each of five equally-spaced depth intervals (1.7, 3.4, 5.1, 6.8, 8.5 m). Whole plants within each quadrat were enclosed in plastic bags and pulled from the soft sediment, then washed in a 0.5 mm mesh sieve. Macrophytes were dried to constant weight at 80°C. for standing crop estimates.

A Yellow Springs Instruments telethermometer was used for temperature measurements, while light (400-700 nm) was measured at midday with a Li-Cor Integrating Quantum Photometer with spherical sensor.

Results and Discussion

Light penetration at the end of May (Table 1) showed a fairly steady decline with depth. At this time, temperature decreased by 4.5°C in the top 9 m, and only a further 0.7°C in the next 16 m to the bottom at Miller Beach. The lake is slow to warm in summer. In June, the greatest warming occurred immediately below the surface (Table 2), but by July, the metalimnion had descended to 5-7 m. Maximum temperatures were achieved in August, with the metalimnion pushed down to just below 8.5 m. Cooling was rapid in the fall, and by November, temperatures at 0-8.5 m were a uniform 5-6°C. Under the ice in December, temperatures in this zone had reached the winter level of 4°C. Ice typically breaks up at the end of April.

Macrophyte growth was restricted to the zone above 8.5 m, with a distinct cut-off at the lower boundary. Such cut-offs have been reported for areas with steep slopes for lakes in Ontario (Dale 1986). Despite claims of local divers that in the past, plants (possibly Charales) could still be encountered as deep as 18-20 m, and despite a search of the study area down to 30 m, none were found below the present zone. Thus temperature was probably more important than light in this restriction, as 1% of available surface light was still present at 11.5 m, and *Zosterella dubia* can survive at less than 1% (Pip and Simmons 1986).

The maximum macrophyte depth of 8.5 m nonetheless exceeded the maximum of 6.8 m for both vascular and nonvascular taxa reported in a survey of 28 stratified Shield lakes in Ontario by Dale (1986). However, when vascular plants only were considered, the limit for these in West Hawk Lake was the same as that cited by Dale (1986). Nonvascular plants penetrated farther in West Hawk Lake. The reason for this greater depth limit is not clear, since in some of the lakes cited by Dale (1986), the 16°C isotherm for mid-July was comparable or deeper than in West Hawk Lake, yet the macrophytes, including Charales, in that study were restricted to shallower water.

Macrophyte communities at Miller Beach were distributed as patches on the sand/silt bottom among intervening areas of bare rock and consisted of nine taxa: *Eleocharis* sp. (Spikerush), *Nitella* sp. (Nitella), *Chara globularis* (Muskgrass), *Potamogeton amplifolius* (Bigleaf Pondweed), *P. robbinsii* (Fern Pondweed), *P. gramineus* (Variable Pondweed), *P. epihydrus* (Ribbonleaf Pondweed), *P. richardsonii* (Richardson's Pondweed) and *Zosterella dubia* (Water Stargrass). The macrophytes at Miller Beach

TABLE 1. Vertical midday light intensity profile for Miller Beach on 31 May 1989.

Depth (m)	Light ($\mu E/m^2/sec$)
Air	2710
0 (below surface)	1970
1	1380
2	740
3	410
4	320
5	204
6	143
7	88
8	61
9	51
10	36
11	31
12	20
13	16.2
14	13.8
15	5.5
16	3.5
17	2.6
18	1.93
19	1.26
20	0.84
21	0.68
22	0.53

TABLE 2. Temperature (°C) attenuation with depth at Miller Beach in 1989.

Depth (m)	31 May	15 June	14 July	18 August
0	10.1	17.5	23.0	24.5
1.5	8.2	11.2	23.0	22.8
3.5	8.0	10.5	23.0	22.5
5.0	7.5	10.1	22.8	22.5
7.0	6.8	9.5	15.0	22.5
8.5	5.8	8.8	11.0	20.2

TABLE 3. Vertical zonation of macrophytes at Miller Beach.

Quadrat depths (m)	Macrophytes present
1.7	*Zosterella dubia*
1.7 - 3.4	*Eleocharis* sp. *Nitella* sp. *Potamogeton amplifolius* *P. epihydrus* *P. gramineus* *P. richardsonii*
1.7 - 6.8	*P. robbinsii*
3.4 - 8.5	*Chara globularis*

were the same as those found in other areas of the lake. While this species richness was comparable to the average for lakes in central Canada (Pip 1987), it was below that of other Shield lakes in the area, for example Shoal Lake, which contains 32 species (Pip and Sutherland-Guy 1987).

Species richness per quadrat, averaged for the season, was significantly inversely correlated with depth ($r = -0.98$, $p = 0.002$, $n = 5$) (both variables log transformed), with a maximum of 3 at the 1.7 m level. Such an inverse relationship has also been reported for more productive Shield lakes in the area, although species richness per quadrat may be as great as 12 (Shoal Lake) (Pip and Sutherland-Guy 1987).

The macrophyte communities showed a distinct vertical zonation in terms of composition (Table 3), with seven of the nine taxa limited to the shallowest zone. *Chara* was consistently found in the lower portion of the macrophyte zone, at the intervals from 5.1 to 8.5 m, and was encountered only once at 3.4 m. A similar observation has been reported by Dale (1986) for stratified lakes in Ontario, where the Charales were the most frequent plants at the deepest strata. While the vascular *Zosterella dubia*, and particularly nonvascular taxa such as *Chara* and *Nitella* may attain considerably greater depths in some situations (Hutchinson 1975; Pip and Simmons 1986), in the study area all macrophytes were apparently absent below the maximum penetration of the thermocline. A similar limitation of growth to the epilimnion has been reported by Moeller (1980), who suggested that length of the growing season may be significantly shorter at the lower temperatures found at greater depths and may thus impose a limit on macrophyte distribution.

Standing crop within the macrophyte patches was greatest during May, June and July (Table 4), and thus the times of peak biomass did not coincide with the warmest water temperatures. As expected, the 1.7 m level, where vascular species predominated and light intensities were greatest, showed the highest mean standing crop averaged over May-September of all the depth intervals sampled, even though values very quickly declined during the summer. Production by vascular plants at 3.4 m was substantially smaller, and a distinct increase in production occurred at 5.1 m, where *Chara* began to predominate. However mean seasonal biomass in the *Chara* zone decreased steadily with further depth. *Chara* persisted throughout the entire year, and biomass at 5.1 m had already increased by December. Vascular plants started to grow while ice cover was still present, and *P. amplifolius* had grown to 0.5 m in length by the time of ice breakup.

Biomass within the plant stands was low compared with values for more productive Shield lakes, for example nearby Shoal Lake, where maximum values of more than 900 g/m^2 at 1.5 m have been reported (Pip and Sutherland-Guy 1987).

Seasonal biomass changes were poorly correlated among the five depths over time, indicating that generalizations of growth patterns could not be made for the macrophyte communities as a whole. Similarly, relative vertical distribution patterns for biomass did not remain constant during the season. Vertical patterns for May were significantly correlated with those for September ($r = 0.99$, $p = 0.001$) and November ($r = 0.86$, $p = 0.03$), and September and November were correlated with each other ($r = 0.91$, $p = 0.015$). Patterns for June and July were separately intercorrelated ($r = 0.83$, $p = 0.04$).

TABLE 4. Summary of standing crop estimates at Miller Beach. Values are g/m^2 dry weight.

	Depth (m)				
	1.7	3.4	5.1	6.8	8.5
24 May	29	13	128	110	49
15 June	162	9	54	74	50
14 July	115	18	49	14	59
18 August	25	7	40	18	—
10 September	13	7	45	40	13
15 November	9	14	38	29	3
9 December	5	—	65	18	3
Ice-free season mean (± S.E)	69 (30)	11 (2)	63 (16)	51 (18)	43 (10)

TABLE 5. Mean seasonal proportions of gastropods at each sampling depth.

	Depth (m)				
Organisms	1.7	3.4	5.1	6.8	8.5
Valvata sincera sincera Ribbed Valve-snail	0	0	0.06	0.37	0.27
V. tricarinata Three-keeled Valve-snail	0.12	0.14	0.09	0.11	0.13
Amnicola limosa Ordinary Spire-snail	0.40	0.57	0.41	0.21	0.47
A. walkeri Small Spire-snail	0	0	0.03	0	0
Gyraulus deflectus Irregular Gyraulus	0.16	0.14	0.03	0.05	0
G. parvus Modest Gyraulus	0.28	0.14	0.29	0.16	0.07
Promenetus exacuous Keeled Promenetus	0.04	0	0	0	0
Helisoma anceps royalense Lake Superior Ramshorn	0	0	0.06	0.11	0
Fossaria exigua Graceful Fossaria	0	0	0	0	0.07
Physa gyrina Tadpole Snail	0	0	0.03	0	0

Ten species of gastropods (Table 5) [nomenclature after Clarke (1981)] were found associated with the macrophyte stands, in addition to insect trichopteran and chironomid larvae. A single species of pea clam (*Pisidium compressum*) was also observed in the stands throughout the entire depth range sampled, but was excluded because it is primarily a sediment dweller (Servos et al. 1985). Shells of molluscs were thin and eroded due to the low availability of carbonate in the lake. Numbers of species (Table 5) showed a maximum at the 5.1 m interval. Numbers of individuals on the macrophytes per square meter of bottom area were also marginally greatest at 5.1 m during the season (11.3 ± 4.1 S.E.), although analysis of variance showed that vertical density differences were not statistically significant. The overall seasonal mean was 10.1 (± 1.7) snails /m^2 , all depths considered.

Analysis of variance indicated that significant seasonal differences existed ($F = 6.76$, $p = 0.008$), with the greatest numbers of snails (16.8 ± 1.7) observed on the plants in May at all depths, when adults from previous seasons' cohorts were still present (e.g. Rooke and Mackie 1984). Lowest densities were seen in June (4.4 ± 0.4), and increased steadily to 11.0 (± 1.0) by September, presumably as a result of new recruitment from reproduction. Numbers of individuals were not significantly correlated with plant biomass at the various depths.

Amnicola limosa was numerically the most abundant species on the macrophytes at all depths. This species has been reported to dominate the gastropod communities of other Shield lakes at low alkalinities (Rooke and Mackie 1984). Of particular interest was the genus *Valvata*: while the importance of *V. tricarinata* remained relatively constant at all depths, *V. sincera sincera* occurred only at the 5.1 m and deeper intervals, coinciding with the distribution of *Chara*, and achieved a substantial percentage at the 6.8 and 8.5 m levels. Analysis of variance of arcsine transformed data (Sokal and Rohlf 1981) showed that these vertical differences were highly significant ($F = 8.90$, $p = 0.0007$). The ecology of *V. sincera* is not well known, and it occurs only infrequently in central North America (Pip 1988). However, its habitat in West Hawk Lake supports the observations of Baker (1928), who reported it from deep water in the Great Lakes. Vertical differences were not significant for other species.

While *Valvata* and *Amnicola* are gill-breathers, the remainder of the gastropods are pulmonates. Their occurrence at greater depths suggests that they obtain their oxygen from the plants with which they are associated, as at these depths it is impractical for them to come to the surface to breathe. The largest species, *Helisoma anceps royalense*, was encountered only at the 5.1 and 6.8 m levels; this is a very rare subspecies in Manitoba.

Vertical zonation of littoral communities has been reported for other Shield lakes (e.g., Adamstone 1924; Pip and Sutherland-Guy 1987), but the controlling factors differ with situation. While light may be the most important in warmer, well-aerated lakes (Pip and Sutherland-Guy 1987), in West Hawk Lake temperature appeared to be the overriding factor. Species richness was low, and productivity within

the macrophyte stands, even with the exclusion of the large expanses of uncolonized areas within the upper 8.5 m zone, was substantially lower than that in nearby warmer Shield lakes, with uncolonized areas included (e.g., Pip and Sutherland-Guy 1987). When the sparse standing crop of submerged macrophyte and associated invertebrate communities is considered together with the limited amount of bottom area that is less than 8.5 m deep around the circumference of the lake, the contribution of these communities in relation to lake volume appears to be quite small compared to shallower Shield lakes which are often dominated by submerged vegetation.

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Distribution, Abundance, and Aspects of Breeding Ecology of Black Scoters, *Melanitta nigra*, and Surf Scoters, *M. perspicillata*, in Northern Quebec

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In northern Quebec and Labrador, the breeding ranges of Black Scoter (*Melanitta nigra*) and Surf Scoter (*M. perspicillata*) correspond roughly to the subarctic zone. Near Lake Bienville, Quebec, Black Scoter broods were more abundant (4-14/100 km^2) than those of Surf Scoters (2-5/100 km^2), and higher than elsewhere in North America. Brood density estimates derived from single aerial surveys were nearly half those derived from repeated surveys of an area. The breeding chronology of both scoter species was similar with laying beginning in the first week of June and broods hatching in the 2nd and 3rd weeks of July. Duckling mortality was high. Newly hatched Surf Scoters spent 60% of their time feeding whereas the attending females spent only 30%. Brood feeding periods (37.3 ± 3.6 minutes) were longer than resting periods (22.2 ± 4.1 minutes). Resting periods averaged longer on land ($\bar{x}$ = 24.9 ± 2.8 minutes) than on water ($\bar{x}$ = 15.4 ± 2.2 minutes). Timing of feeding and resting activities probably affect the accuracy of aerial surveys for scoters on the breeding grounds.

Key Words: Black Scoter, *Melanitta nigra*, Surf Scoter, *Melanitta perspicillata*, aerial surveys, breeding densities, brood densities, time budget, waterfowl, northern Quebec.

Black Scoters (*Melanitta nigra*) and Surf Scoters (*M. perspicillata*) are the least studied waterfowl of North America (Johnsgard 1975; Palmer 1976; Godfrey 1986). The few studies on these species have focused mainly on courtship (Myres 1959a,b; McKinney 1959; Palmer 1976), wintering ecology (Stott and Olson 1973, 1974; Vermeer 1981; Vermeer and Bourne 1984; Goudie and Ankney 1986), or general distribution and densities (Bellrose 1978; Palmer 1976; Godfrey 1986; Goudie and Whitman 1987). No breeding biology studies have been published to date on the North American populations (Godfrey 1986) although a few studies have been conducted on the breeding ecology of the European Black Scoter (Bengtson 1966, 1970, 1971).

Between 1975 and 1980, Hydro-Québec commissioned several studies to assess waterfowl breeding densities near their proposed northern hydro-electric developments (Bider and Lamothe 1982). These studies provided important information on the distribution and abundance of Black and Surf scoters in northern Québec, and some preliminary data on brood behaviour. Unfortunately this information is contained in various consultant reports and is not readily accessible.

Here, we summarize data collected in 1976 during a commissioned study and review some of the published and unpublished reports containing distribution and abundance data on Black and Surf scoters breeding in Quebec and Labrador.

Study Area

The areas surveyed included the watersheds of Great Whale River, Little Whale River and coastal areas of Hudson Bay from the mouth of Great Whale River to Guillaume-Delisle Lake, and covered 600 000 km^2 of diverse habitats (Figure 1). The focal point of the study area was Lake Bienville (Area 1) where 1047 km of transects were flown. Three smaller areas were sampled. Area 2: The Vaujours area, to the northwest of Lake Bienville, which included Vaujours, Saindon and Mollet lakes, and which differed from the Lake Bienville area, having a more mountainous terrain and an absence of large networks of string bogs. A total of 438 km of transects was surveyed in this sector. Area 3: The Caniapiscau area to the east of Lake Bienville which, like the Vaujours area, was more mountainous. This sector was covered by 231 km of transects. Area 4: The Hudsonian plateau, which comprised an inland sector near the coast bordered to the south by the Great Whale River, to the north by the Boutin River, and to the east by the Coast River. Fifty small lakes were surveyed in this sector along an 88 km transect. Lakes of this sector were on old marine deposits and tended to have more aquatic vegetation than the lakes of other sectors.

Methods

Aerial surveys in 1976 were conducted from a Bell 206 Jet Ranger helicopter at speeds of 100 to 145 km/hour and a height ranging between 60 and 90 m. The crew included a pilot, a navigator and two

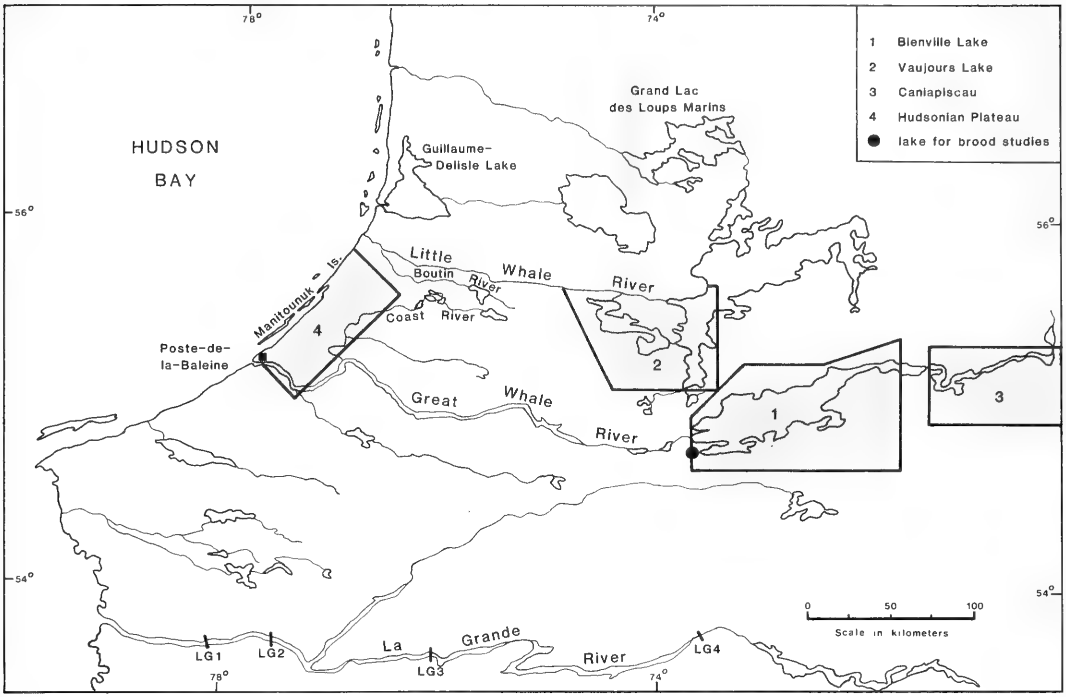

FIGURE 1. Location of waterfowl survey areas in 1976.

observers. Each sector was surveyed along series of parallel flight lines 4 to 10 km apart. Flight lines were followed until birds were spotted, then the helicopter left the flight line to approach the birds so that they could be identified. Usually, the navigator made the identification and the two observers counted the birds. Following identification the flight line was resumed until other birds were detected. Transect width was not fixed but varied with weather and habitat, although we estimated that it averaged 0.5 km. Most flights were conducted during calm weather. To complement transects, each of 24 randomly selected plots of 3.25 km^2, placed along transect lines in the Lake Bienville area, were thoroughly surveyed from the air.

To estimate brood density, we combined the results of two surveys of the same transect lines, conducted three weeks apart (24-26 July 1976 and 16-24 August 1976). During each survey, broods were spotted and mapped and the number of young and their estimated age recorded (after Taber 1971), to determine whether or not broods were resighted. We assumed, from daily observations on some lakes that overland brood movements were negligible. Incubation was assumed to last 30 days for both species of scoters (after Cramp and Simmons 1977).

Brood behavior was studied on a small lake (Figure 1) which supported five scoter broods. Two broods were followed continuously during daylight hours for 2 days, using focal sampling (Altman 1974), and the behavior of the females and young was recorded as swimming, sleeping, preening (regrouped as resting for analysis), feeding, and watching (for female only). Because of frequent brood mixing the size of groups under observation ranged from 8 to 28 young.

Results

Over 95% of the birds seen from the air were identified. Scoters, with mergansers and Canada Geese (*Branta canadensis*) were the most abundant species of waterfowl breeding within the study area (Table 1). Only one brood of White-winged Scoter (*Melanitta fusca*) was observed, and Black Scoters were more numerous than Surf Scoters along the survey route.

Seasonal Abundance of Scoters

Greater numbers of scoters were seen in early June than in July and August for all sectors, except coastal areas (Table 2). Along coastal transects, Black Scoter numbers peaked in August, whereas numbers of Surf Scoters peaked in late September (Table 2). Spring concentrations of Black Scoters were observed on the coast and on the rivers, but spring concentrations of Surf Scoters were only seen on rivers. Few scoters were observed on rivers during the summer.

Breeding Densities

Black Scoters were more abundant than Surf Scoters during the breeding season in the three main

TABLE 1. Number of waterfowl observed during 1830 km of transects in Northern Québec in 1976.

	25-29 July			14-21 August		
	No. of adults	No. of broods	No. of young	No. of adults	No. of broods	No. of young
Red-throated Loon (*Gavia stellata*)	13	3	3	7	3	3
Common Loon (*Gavia immer*)	28	7	9	34	9	10
Canada Goose (*Branta canadensis*)	451	20	73	291	46	157
Green-winged Teal (*Anas crecca*)	0	0	0	45	0	0
American Black Duck (*A. rubripes*)	31	3	18	56	1	9
Mallard (*A. platyrhynchos*)	2	1	4	1	1	6
Pintail (*A. acuta*)	1	0	0	21	0	0
Scaup sp.	8	2	19	11	9	55
White-winged Scoter (*Melanitta fusca*)	1	1	4	1	1	4
Surf Scoter (*M. perspicillata*)	34	19	101	18	17	71
Black Scoter (*M. nigra*)	49	29	151	29	25	117
Scoter sp.	3	3	12	2	2	23
Common Goldeneye (*Bucephala clangula*)	7	0	0	9	0	0
Hooded Merganser (*Lophodytes cucullatus*)	68	0	0	86	0	0
Merganser sp.	233	14	105	311	43	236
Duck sp.	11	0	0	9	0	0
TOTAL	940	102	499	931	157	691

Greater Scaup (*Aythya marila*) and Lesser Scaup (*Aythya affinis*).
Common Merganser (*Mergus merganser*) and Red-breasted Merganser (*Mergus serrator*).

inland sectors (Bienville, Vaujours and Caniapiscau) (Table 3). On Hudson Plateau, the scoter population was small. Densities of Black Scoters ranged from two broods per 100 km^2 on the Hudson Plateau to 11 per 100 km^2 in the Caniapiscau area (Table 3). No broods were seen on coastal transects, and very few on rivers. The 24 sampled plots of the Lake Bienville area confirmed the relatively high densities of scoters in this area (Table 4).

Density estimates derived from single surveys were approximately half those derived from repeated surveys of an area. In the most intensively sampled Lake Bienville region, the July survey yielded 28 scoter broods, versus 30 in August. However, aging and mapping of broods along the surveyed route indicated that most broods observed during the two surveys were different. Furthermore, the 24 plots surveyed yielded 10 broods that were not detected in the transects. A total of 68 different broods were recorded in the surveyed area and this yielded a density estimate of 13.0 broods/100 km^2 (Table 3).

Breeding Phenology

Five pairs of Surf Scoters and one pair of Black Scoters were observed daily on a small lake near Lake Bienville. Lone males were first recorded on 11 June, and by 17 June four males were alone on the lake suggesting that some females had started incubating. On 13 July, three newly hatched broods were seen on the lake. Assuming an incubation period of 30 days, incubation was initiated around 13 June which corresponds to the observation of lone males on the lake.

Aging broods from the air is crude but can permit a comparison between species (Table 5). Black Ducks were the earliest breeders followed by Canada Geese, Greater Scaup, scoters and mergansers which initiated nesting in the second week of June, two to three weeks after Black Ducks. The first brood of

TABLE 2. Seasonal abundance of Black Scoters (B) and Surf Scoters (S) in 1976. (Number of adults seen.)

Area	June 4-7 B/S	July 25-28 B/S	August 15-18 B/S	Sept. 5-7 B/S	Sept. 12-14 B/S	Sept. 19-21 B/S	Sept. 24-27 B/S
Bienville	90/43	66/25	55/25	47/18	63/9	24/9	14/31
Hudson Plateau	13/32	0/7	3/16	0/24	3/29	1/21	0/5
Hudson Coast	134/7	0/0	639/25	60/37	10/6	10/305	70/202
Great Whale River	180/65	0/0	0/0	0/0	1/19	12/15	7/32
Coast River	39/5	1/0	0/5	0/0	0/14	2/17	5/5
TOTAL	456/152	67/32	697/71	107/79	77/77	49/367	96/275

TABLE 3. Scoter brood density (broods/100 km²) in various sectors of Northern Québec in 1976. (Transect width = 0.5 km; based on two surveys, 24-26 July and 14-16 August).

Area	Transect Length (km) (area km²)	Surf Scoter No. broods/ No. young	Black Scoter No. broods/ No. young	Scoter sp. No. broods/ No. young	Total No. broods/ No. young
Bienville	1047 (524)	26/121 (5.0)[1]	38/194 (7.3)	4/14 (0.8)	68/329 (13.0)
Vaujours	438 (219)	4/14 (1.8)	9/42 (4.1)	0/0	13/56 (6.0)
Caniapiscau	231 (116)	6/26 (5.2)	13/56 (11.2)	2/6 (1.7)	21/88 (18.1)
Hudson plateau	115 (57)	2/14 (3.5)	1/2 (1.8)	2/8 (3.5)	5/24 (8.8)
Hudson coast	68	0/0	0/0	0/0	0/0
Great Whale River	364	0/0	0/0	0/0	0/0
Coast River	99	1/4	0/0	0/0	1.4

[1]Number of broods per 100 km²

Black Ducks was observed in the third week of June, whereas that of scoters in the second week of July. Thus, it is likely that the July survey missed late hatching scoter broods, and the August survey missed early fledging broods and broods that died prior to fledging.

Brood Ecology

Four of the five Surf Scoter pairs observed on the small lake hatched a brood. No broods were observed on the lake on 11 July. Three broods of 6, 11, 13 young Surf Scoters were observed on 13 July. On 15 July there were only two broods on the lake, one with 8 young and the other with 20 young, indicating that brood amalgamation may have occurred. One lone female was present on the lake. On 23 July, only one female with 9 young and 15 unattended young were scattered on the lake. On 26 July, a Black Scoter with 5 newly hatched young was observed, and two days later a lone female Black Scoter and 10 young Surf Scoters were present. A survey of neighbouring lakes from a helicopter did not yield any scoters. Five lakes known to have scoter broods were surveyed on 25 July and 10 August. On 25 July, 14 broods of scoters were seen with 101 young, whereas on 10 August only 4 broods with 17 young were recorded, suggesting heavy mortality among broods. The unusually cold weather and heavy rain recorded during the first week of August may have contributed to this high mortality.

Two newly hatched Surf Scoter broods alternated feeding and resting periods throughout the day. Young birds spent 60% of their time feeding, compared to only 30% for adult females who spent most of their time (40%) watching over their offspring (Figure 2). Feeding periods of young averaged 37.3 ± 3.6 minutes (range 4-88, n = 28), and were significantly longer on average than resting periods which averaged 22.2 ± 4.1 min (range 3-122, n = 31, T = 2.78, df = 55, P = 0.07). Resting periods tended to be longer in the afternoon (30.9 ± 7.5 min, n = 14) and shorter in the evening (8.0 ± 1.7 min, n = 7) than in the morning (19.0 ± 3.0 min, n = 10). However, the differences were only statistically significant between afternoon and evening (Tukey test, $P < 0.05$). Broods rested on water and along the edge of ponds. Resting periods on water averaged 15.4 min ± 2.2 and were significantly shorter than those on land 24.9 ± 2.8 min (T = –2.677, P = 0.012, df = 28). Feeding activity peaked just after sunrise and just before sunset.

TABLE 4. Number of scoter broods observed (number of broods/ number of young) in 1976 in the sector of Bienville Lake as derived from surveys of twenty-four 3.25 km² sampled plots. (Total area = 78 km²).

Species	July 24-26	August 14-16
Surf Scoter	2/4 (2.6)[1]	3/11 (3.9)
Black Scoter	6/29 (7.7)	10/33 (12.8)
TOTAL	8/33 (10.3)	13/44 (16.7)

[1]Brood density (brood/100 km²).

Discussion

Seasonal Abundance of Scoters

The summer variation in scoter abundance is caused by the departure of males for molting

TABLE 5. Number of broods classified in various age groups after Taber (1971) in 1976 during the 26-28 July survey (regular numbers) and the 14-18 August survey (number in parentheses).

	AGE CLASS					
	I			II		
	A (0-1 week)[1]	B (1-2 weeks)	C (2-3 weeks)	A (3-4 weeks)	B (4-5 weeks)	C (5-6 weeks)
Canada Goose	0	7	38	(12)	(22)	0
Black Duck	0	0	0	3	0	(1)
Greater Scaup	1	1(2)	(1)	(2)	0	0
Surf Scoter	1	8	5(5)	(8)	(1)	0
Black Scoter	3	13	3(6)	(15)	(2)	0
Merganser	10	8(9)	(13)	(8)	0	0

[1]Values based on Lesser Scaup. Exact age representing the age classes, varies with species.

grounds. Consequently, high numbers observed on the coast in July and August are probably due to the presence of molting males. Coastal areas of James Bay, Hudson Bay, Ungava Bay and Labrador are used by scoters for molting. For example, Ross (1983) estimated that 90 000 Black Scoters molted in the James Bay area.

Breeding Density of Scoters

Both Black and Surf Scoters bred in relatively high densities in the Lake Bienville area. Unfortunately, our transect design did not allow us to estimate the precision of our counts, thus our comparisons are limited to the area surveyed. White-winged Scoters were observed occasionally, but only one brood was seen over four years of surveys (Bider and Lamothe 1982). This represented the first documented breeding by this species east of Manitoba. Review of other estimates of density for Scoters point to Lake Bienville as a significant area for Surf and Black scoters (Tables 6-7, Figure 3). However, only a small portion of northern Québec has been adequately surveyed to date. In Labrador,

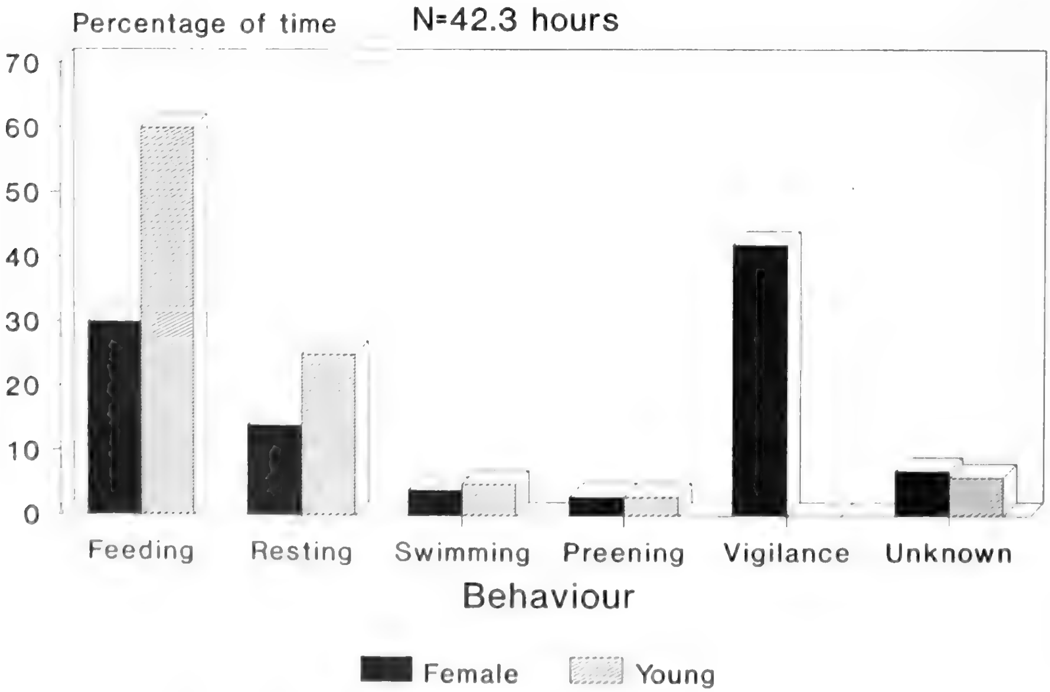

FIGURE 2. Time budget of newly hatched Surf Scoter broods.
(n = 42.3 hours of observations distributed equally on two broods over 2.5 days).

TABLE 6. Breeding pair density of scoters in various areas of Quebec and Labrador (see Figure 3).

Area	(Source)	Area surveyed (km^2)	Date	Density (pairs/100km^2)	Ratio surf/black
A	(Gillespie and Wetmore 1974)	1396	6-11 June 1970	1.9	10:1
A	(Gillespie and Wetmore 1974)	1134	6-11 June 1970	1.9	10:1
A	(Gillespie and Wetmore 1974)	1021	28-31 May 1971	0.3	—
A	(Gillespie and Wetmore 1974)	1021	8-11 June 1972	0.9	—
A	(Goudie and Whitman 1987)	1200	3-11 June 1980	2.6	3:1
A	(Goudie and Whitman 1987)	1100	3-11 June 1980	2.2	3:1
B	(Gillespie and Wetmore 1974)	?	6-9 June 1970	0.4	—
C	(Gillespie and Wetmore 1974)	?	15-30 June 1970	0.0	—
D	(Goudie and Whitman 1987)	1900	12-21 June 1980	1.0	3:1
F	(Savard 1977)[1]	523	4-7 June 1976	18.0	6:12
H	(Lehoux and Rosa 1973)	1508	July 1972	0.1	—
I	(Bordage 1987)	5000	11-26 May 1985	1.9	1:1
I	(Bordate 1988)	5000	12-27 May 1986	0.1	1:0

[1]Unpublished reports which can be consulted at Hydro-Quebec Documentation Centre, Direction Environment, 870 Maisonneuve, Montreal, Quebec:

Lehoux, D., and **J. Rosa.** 1973. Description des principale unités physiographiques de la région de la Baie James. Regional Report, Canadian Wildlife Service Quebec Region. 112 pages.

Savard, J-P. L. 1977. Étude de la faune avienne dans les bassins de la Grande Rivière de la Baleine et de la Petite Rivière de la Baleine (été 1976). Eco-Researach Inc. Report for the environmental section of Hydro-Quebec, GB-BIO-77-3.200 pages. Results presented in this paper.

few scoters breed along the coast but moderate densities occurred in the Churchill Falls area (Gillespie and Wetmore 1974; Goudie and Whitman 1987). Similarly, few breeding scoters have been recorded in the inland area adjacent to James Bay (Tables 7-8). Intensive surveys in the boreal forest between 48°N and 51°N latitude indicated low densities of breeding scoters but increasing densities with increasing latitude (Bordage 1987, 1988). All estimates of density of broods found in the literature were based on single counts and probably underestimated true density. In the Lake Bienville area, single counts recorded less than half of the actual brood density. Bordage (personal communication) compared simultaneous helicopter and ground surveys in an area just south of the study area and found a visibility index of 40% for scoter pairs and 66% for scoter broods. Goudie and Whitman (1987) measured the effectiveness of aerial surveys compared to ground coverage of the same areas in Labrador and obtained a visibility index ranging between 30 and 50% for pairs of scoters surveyed from the air. However, Haapanan and Nilsson (1979) reported an efficiency of 80% for pairs of Black Scoters in Sweden. Air:ground comparisons have often not been well synchronized. This possibly contributed to the varying ratios observed. More research is needed to understand the causes of this variability. However, it is likely that pair estimates presented in Table 7 are under-estimates possibly ranging between 20 and 70% of true values.

Densities of Black and Surf scoters breeding in the Lake Bienville area were the highest reported to date in North America. This suggests that the area may be prime nesting habitat for these two species of scoters. The zone of high nesting densities of Black and Surf scoters in Quebec roughly corresponds to the Hemiarctic (subarctic) zone (Rousseau 1972; Ducruc et al. 1976) whereas their general breeding area would be enclosed in the forest and tundra region described in Hosie (1972). Further south in the boreal forest, Black Ducks become the dominant species with breeding densities ranging between 10 and 24 pairs per 100 km^2 (Bordage 1987; Ross 1987) and scoter densities are lower (2 pairs/100 km^2, Bordage 1987). However, Bordage's surveys were conducted early in the season for Black Ducks and have likely underestimated scoter density. DesGranges and Houde (1988) found Black Scoters only on lakes of the Taiga and Muskeg areas, and none within the boreal forest. However, the number of lakes they surveyed was small.

Breeding Chronology and Brood Ecology

Scoters are late breeders compared to Canada Geese and Black Ducks. Scoters showed an aggregated distribution over the surveyed area. This aggregated distribution may reflect habitat availability. Scoters appeared to prefer shallow and rocky lakes and avoided rivers and large, deep lakes. DesGranges and Houde (1988) indicated that Black Scoters preferred productive Taiga lakes. Goudie and Whitman (1987) noted scoters preferred rocky-shored lakes. More research is needed to identify the factors influencing scoter distribution on their breeding areas.

TABLE 7. Brood density of scoters in various areas of Quebec (see Figure 3). (All estimates derived from single counts and not corrected for detectability.)

Area	(Source)	Area surveyed (km²)	Date	Density (broods/100 km²)
A	(Gillespie and Wetmore 1974)	1160	20-27 July 1970	0.3
A	(Gillespie and Wetmore 1974)	2055	1 August-26 July 1971	0.4
E	(Savard 1977)[1]	116	19 July 1976	11.0
E	(Savard 1977)[1]	116	18 August 1976	6.0
E	(St-Louis 1982a)[2]	91	16-24 August 1977	1.1
F	(Plante 1975)[2]	440	4 August 1975	4.8
F	(Savard 1977)[1]	523	24-26 July 1976	5.4
F	(Savard 1977)[1]	523	14-16 August 1976	5.4
F	(St-Louis 1982a)[2]	421	16-24 August 1977	2.6
F	(St-Louis 1982b)[2]	397	22-29 July 1978	5.3
G	(Savard 1977)[1]	219	28 July 1976	4.6
G	(Savard 1977)[1]	219	17 August 1976	2.3
G	(St-Louis 1982a)	174	16-24 August 1977	0.6

[1]See Table 6.
[2]Unpublished reports which can be consulted at the Hydro-Quebec Documentation Centre, Direction Environment, 870 Maisonneuve, Montreal, Quebec:

Plante, P. 1975. Project d'aménagemant hydroélectrique Grande Rivière de la Baleine. Inventaires préliminaires. Faune avienne et terrestre, été 1975. Hydro-Québec, Section Environnement. 74 pages.

St-Louis, N. 1982a. Étude de la faune avienne dans les bassins de la Grande Rivière de la Baleine et de la Petite Rivière de la Baleine (été 1977). Eco-Research Inc. Report for the environmental section of Hydro-Quebec, GB-BIO-ECO-78-4. 159 pages.

St-Louis, N. 1982b. Étude de la faune avienne dans les bassins de la Grande Rivière de la Baleine et de la Petite Rivière de la Baleine (été 1978). Eco-Research Inc. Report for the environmental section of Hydro-Quebec, GB-BIO-ECO-79-5. 128 pages.

Time budgets of female Surf Scoters with young were similar to those measured in Barrow's Goldeneye (Savard 1988) as females spent less time feeding than young but more time in vigilance. Young broods rested often on land, a behavior that may account for their low detectability from the air. Evening surveys would locate more broods than afternoon surveys as resting periods were shorter in the evening. Such behaviour should be considered in the planning of surveys. The high duckling mortality observed, and apparent frequent brood amalgamation deserve further studies. Koskimies (1955) and Koskimies and Routamo (1953) recorded high duckling mortality in a population of Velvet Scoter (*Melanitta fusca*) in Finland and attributed it to loose parent-young bonds and bad weather. Much of this area supports significant populations of Northern Pike (*Esox lucius*), a noted predator of young waterfowl. Greater understanding of the ecology of breeding scoters is important for proper management of the species, especially with the impending hydro-electric development in the centre of their breeding range and the extremely liberal hunting season and bag limits on their central winter range.

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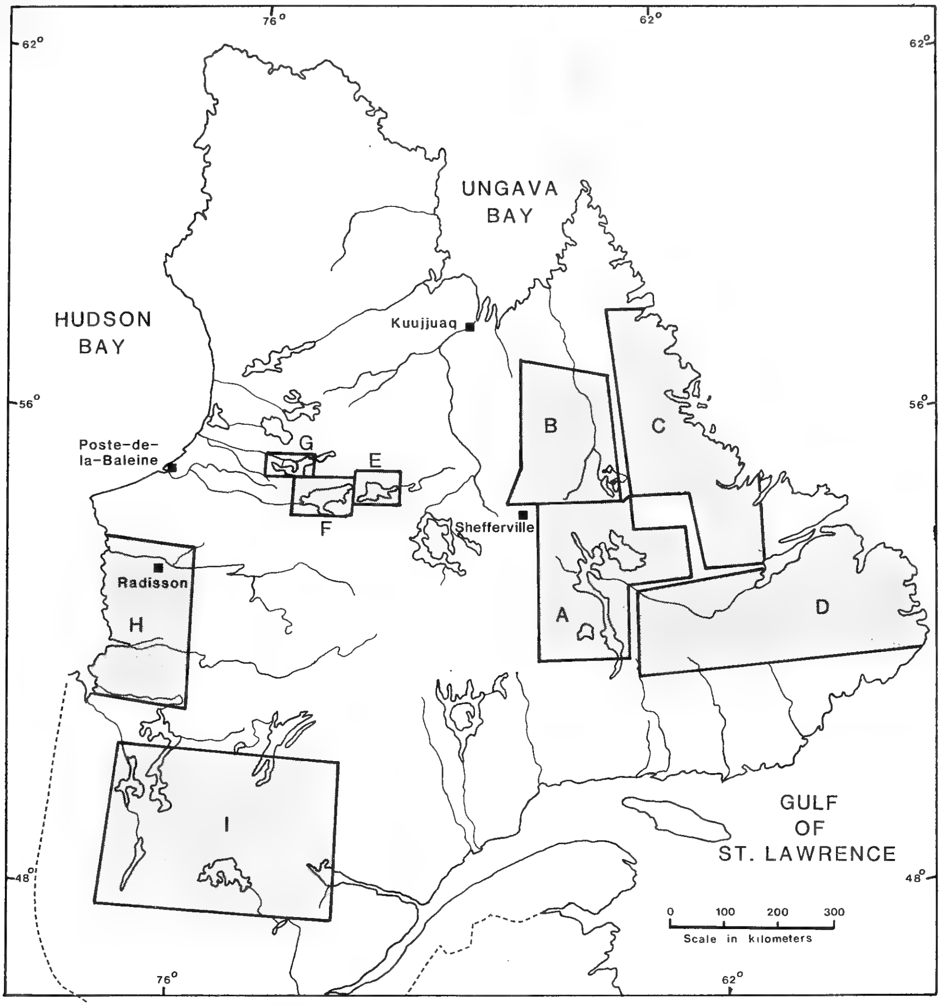

FIGURE 3. Location of waterfowl surveyed areas in Northern Quebec.

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Den Site Activity Patterns of Gray Wolves, *Canis lupus*, in Southcentral Alaska

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Den site attendance and activity patterns of Gray Wolves within two wolf packs in southcentral Alaska were studied in 1980 and 1981 using a combination of activity radio transmitters and direct observations from blinds and fixed-wing aircraft. One wolf pack was electronically monitored for 17 continuous days in 1980 and another for 43 continuous days in 1981. They were observed for 277 and 369 hours, respectively. Alpha females spent more time at dens than other pack members. The alpha female of a pack of four adult wolves spent less time at the den than did the alpha female from a pack of eight adult wolves suggesting that in smaller packs, alpha females may have a more active role in providing food for pups. Den attendance by other pack members was highly variable. Yearling males tended to avoid dens until after parturition. Yearling females from the large pack tended to spend more time at the den than those from a smaller pack. When pups were from 2-7 weeks of age, they were left unattended from 5-15% of the time. There was a high probability that groups of wolves would be present at the den during mid-day. Wolves tended to depart from the den between 2100 and 2400 h and arrive between 2100 and 0400 h.

Key Words: Gray Wolf, *Canis lupus*, summer, activity, attendance, den site, homesites, Alaska

Gray Wolf (*Canis lupus*) summer activities are centered around den and rendezvous sites for the raising of pups. Adult and yearling wolves share in providing nourishment for pups by hunting and returning to homesites to regurgitate food to pups, but the amount of food contributed varies by sex, age, hunting experience, social status, and other factors (Mech 1970). The contribution of individual wolves to pup survival may be particularly important in populations that experience high mortality. If hunting, trapping, and other mortality remove key individuals which contribute food to pups, pup survival or health could be influenced. Several studies conducted in areas of little to no human exploitation have described behavior patterns of wolves at homesites (Murie 1944; Joslin 1966; Harrington and Mech 1982). However, only Harrington and Mech (1982) provide quantitative data concerning attendance and behavior by individual wolves by sex and age class.

The purpose of this study was to quantify and compare den attendance and level of activity of adult and yearling wolves for two packs in southcentral Alaska. At the onset of denning, the Susitna pack in 1980 numbered four wolves (two adults and two yearlings), while the Watana pack in 1981 numbered eight wolves (three adults and five yearlings). Both packs had abundant prey. We hypothesized that the Susitna alpha female would spend more time away from the den to hunt because she would lack adequate food contributions from the three remaining pack members. At the Watana den, we expected the alpha female and yearlings to spend significantly more time at the den due to the pack's relatively large size. We expected yearlings from the Watana pack to meet their own food needs, provide more food to the pups, and spend more time at the den than yearlings from the Susitna Pack (Harrington et al. 1983).

Study Area

The study occurred in the upper Susitna Basin of southcentral Alaska located approximately 325 km northeast of Anchorage. Topography, elevation, climate, vegetation, and fauna of the area have been described (Skoog 1968; Bishop and Rausch 1974; Ballard 1982; Ballard et al. 1987). Briefly, vegetation along the Susitna River and its major tributaries was dominated by spruce (*Picea glauca* and *P. mariana*) and birch (*Betula papyrifera*). Generally, above 800 m vegetation was dominated by willow (*Salix* spp.) and Dwarf Birch (*Betula glandulosa*) giving way to mat and cushion and shrub tundra at elevations > 950 m. The Susitna pack, studied in 1980, denned along the Susitna River, south of the mouth of Tyone Creek. The Watana Pack, studied in 1981, denned north of the Susitna River near the mouth of Watana Creek. Both pack territories intersected portions of the range of the Nelchina Caribou (*Rangifer tarandus*) herd which numbered 18 000 to 20 000 during the study (Bergerud and Ballard 1988). Moose (*Alces alces*) densities were about 600/1000 km^2 (Ballard et al. 1987, 1991). Locations and spatial relationships of wolf pack territories were provided by Ballard et al. (1987).

Methods

During May and June, the pattern of activity at dens of the Susitna Pack (1980) and the Watana Pack (1981) were investigated. Both packs were studied as part of a 10-year study of predator-prey relationships (Ballard et al. 1981a, 1987).

Wolves were captured to attach activity transmitters using methods described by Ballard et al. (1982b). Ages of captured wolves were determined by tooth replacement and wear and previous known history (Ballard et al. 1987). Alpha individuals were identified based upon a combination of known pack histories, known sex and age composition, and behavioral characteristics described by Mech (1970). Individual wolves were identified by the abbreviated pack name (S = Susitna Pack and W = Watana Pack) and the last three digits of their assigned permanent accession number.

Activity transmitters contained a mercury tip switch that caused the signal amplitude and pulse width to vary depending on position of the head and neck of the animal. If the animal's head was immobile, the pulse width of the radio signal decreased. Conversely, when the animal was moving, the pulse rate increased. The transmitters were similar to those described by Beier and McCullough (1988) used on White-tailed Deer (*Odocoileus virginianus*). The radio-transmitter collars were color coded with canvas tape to aid identification of individual wolves.

Within 0.4 km of each den, a 3-m tall monopole antenna was erected and connected to a portable digital data processor which fed into a programmable scanning receiver (Telonics Inc., Mesa, Arizona). The pulse interval (activity) and amplitude (signal strength) of radio signals from individual activity transmitters were recorded on a strip-chart recorder (Gulton Inc., Manchester, New Hampshire) which advanced at a rate of 20.3 cm per hour. The instruments were powered by a 12-volt battery and all were housed in a plastic container for weather protection. Individual collared wolves were monitored once every 3 minutes in 1980 and once every 11 minutes in 1981. A reference transmitter was placed nearby to calibrate activity and attendance of wolf transmitters. Each occasion we arrived and departed from the blind, we marked the date and time on the paper spools so activity data could be calibrated to specific dates and times.

The presence and absence of radio-equipped wolves were grouped into six 4-hour periods. Patterns of arrival and departure were tested by Chi-square analysis (Snedecor and Cochran 1973). Expected values were generated by assuming equal probability of arrival and departure over each period. Total hours each wolf was present at the den was determined by electronic monitoring or ground observation. During periods when the strip-chart recorder was out of paper (Susitna – one period of 56 hours, Watana – four periods totaling 14 hours) ground observations substituted for electronic monitoring. Daily ground observations were made from 8 May – 8 June 1980 and 7 May – 22 June 1981 for the Susitna and Watana wolves, respectively. Time spent away from dens was determined by the number of hours individual wolves were undetected through electronic or ground monitoring. Dates and times wolves were observed away from the den from fixed-wing aircraft were compared with periods wolves were electronically recorded or visually observed at dens.

Behavior of individual wolves electronically monitored was classified each hour as either "active" or "inactive" based on the change in amplitude and period of the recorded radio signal. Gillingham and Bunnell (1985) determined that specific behaviors could not be reliably detected with mercury tip switches. However, Bier and McCullough (1988) reported that highly reliable data on bedded versus active behavior could be attained if sampling interval was adjusted for species and environment. We also could not identify specific behaviors by electronic monitoring but, based on comparisons of visual observations with telemetric data, we believed we could detect periods of inactivity from active periods. For this study, we defined "active" as all physical movements other than those associated with lying or standing. An index to overall activity of the den was obtained by dividing the total number of hours a wolf was active by the total hours the individual was at the den.

Each den was observed by one individual from a blind placed so that den entrances could be accurately monitored without disrupting wolf behavior. Blinds were located 150 m and 280 m from the Susitna and Watana den entrances, respectively. Observation periods ranged from 5-12 hours daily and covered a 32-day period at the Susitna den in 1980 and a 47-day period at the Watana den in 1981. During ground observations, den attendance of radio-collared wolves was determined by manually scanning signals every 30 minutes with a receiver attached to a hand-held 2-element antenna (Telonics). Individual wolves were identified by collar color, radio frequency, and pelage color and pattern. Specific notes on behavior of individual wolves and interactions among wolves were recorded (Foster and Ballard 1985).

Activity away from the den was determined by radio-tracking and visually observing collared wolves from fixed-wing aircraft using methods described by Mech (1974) and Ballard and Whitman (1988). Radio signals were received with a programmable scanning receiver (Telonics). Each radioed wolf was observed about twice per week at irregular hours.

Pack Histories

Susitna Pack: At parturition on 1 May, the pack was composed of alpha female S-295, new alpha male S-305, yearling female S-302, and yearling male S-306. The alpha male and female were equipped with activity transmitters and were monitored continuously by strip-chart recorder. Wolves S-302 and S-306 wore conventional radio collars and were monitored by ground observation, electronic scanning with hand-held antennas, and from fixed-wing aircraft. Based on the parturition date, pups produced this season were not sired by S-305. Six pups were successfully raised during 1980.

Watana Pack: During pup rearing, the Watana Pack numbered eight wolves. Five had activity transmitters: alpha female W-308, yearling female W-324, yearling male W-325, yearling male W-345, and yearling female W-346. One yearling female W-323 had a conventional radio collar, one adult male carried a nonfunctional radio collar, and one adult male was uncollared. On 8 May, W-308 entered the den. Between 1 May and 10 May Watana pack members adult male W-310, yearling male W-344, and one other dispersed. W-323 and W-346 also appeared to have dispersed, traveling 83 km from the den, but they returned to the den on 12 May and remained with the Watana pack for the duration of the study. A total of six pups were successfully raised in 1981.

Results and Discussion

Two Susitna pack members were electronically monitored for 17 days in 1980, while five Watana pack members were continuously monitored for 43 days in 1981 (Table 1). Electronic monitoring commenced at the Susitna den on 20 May 1980 and the Watana den on 8 May 1981 and continued through 10 June and 22 June, respectively. Wolves were observed from blinds near dens for 646 hours: 277 hours at the Susitna den site in 1980 and 369 hours at the Watana den in 1981. Parturition occurred on 1 May 1980 at the Susitna den and between 10-11 May 1981 at the Watana den.

The Watana alpha female (W-308) remained continuously (98%) at the den until 5 June and the pups were 25-26 days old (Table 1). After 5 June, she was absent from the den 2-18 hours daily. Similarly, the Susitna alpha female (S-295) was absent on a daily basis for periods of 2-12 hours after 27 May, when the pups were believed to be 26 days old. However, S-295 was not electronically monitored before 20 May, and the total time spent away from the den before pup weaning could not be determined. Between 9 and 19 May, S-295 was present at the den for 74.5 (83.7%) of 89 total hours of ground observation time. Her longest known absence from the den during that period was seven hours.

Adequate nutrition for pups may be one factor determining when and how long maternal females

TABLE 1. Activity and den site attendance of wolves equipped with activity radio transmitters in two wolf packs located in southcentral Alaska during late May and June in 1980 and 1981.

Pack ID no.[b]	Sex	Age	Pre-weaning[a] No. days monitored	H at den	H active	$\bar{X}$ h/day at den	% obs. at den	% obs. active	Post-weaning No. days monitored	H at den	H active	$\bar{X}$ h/day at den	% obs. at den	% obs. active
S-295	F	Ad	5	83	12	16.6	69.2	14.5	11	198	49	18.0	75.0	24.7
S-305	M	Ad	5	27	7	5.4	22.5	25.9	12	76	22	6.3	26.4	28.9
W-308	F	Ad	29	685	259	23.6	98.4	37.8	14	263	129	18.8	78.2	49.0
W-324	F	Yrl	25	233	125	9.3	38.8	53.6	13	113	61	8.7	36.2	54.0
W-325	M	Yrl	26	124	62	4.8	19.9	41.9	14	63	35	4.5	18.8	55.6
W-345	M	Yrl	29	31	19	1.1	4.5	61.3	14	41	26	2.9	12.2	63.4
W-346	F	Yrl	29	308	160	10.6	44.3	51.9	14	100	43	7.1	29.8	43.0

[a] Pre-weaning period was 1 May - 27 May 1980 and 10 May - 5 June in 1981.
[b] S = Susitna pack and W = Watana pack; yearling male S-302, yearling female S-306, yearling female W-323, one collared W-adult with a nonfunctioning transmitter, and one W-uncollared adult male were monitored from blinds, fixed-wing aircraft, and electronic monitoring by scanning from blind with hand-held antenna (*see* text).

will leave the dens. Harrington and Mech (1982) reported that their alpha female was absent from the den 12 to 20% of the time for periods as long as 17 hours between prenatal and weaning. After weaning and for the next two months, the Minnesota female spent only one-third of her time near the den site. Den attendance of their female prior to weaning was similar to that of the Susitna female in this study but much lower than that of the Watana female. Wolves in the Minnesota pack were food stressed due to low densities of White-tailed Deer (38.5/1000 km^2) (Harrington and Mech 1982). Wolves in our study were not food stressed in terms of Moose, i.e., Moose densities $\geq$ 600/1000 km^2 (Ballard et al. 1990), and appeared to have access to abundant small prey based upon scat analyses (Ballard et al. 1987, and unpublished data). The Susitna female and pups may still have been food stressed if lack of experienced pack members or lack of a committed alpha male caused insufficient food being brought to the den. The Susitna alpha female participated more in hunting than did the Watana alpha female during the pre-weaning period but not during the post-weaning period. Both females, however, spent more time at homesites than did other pack members.

When the alpha females left the dens, it was for brief periods compared to other pack members (Table 2). All excursions for Watana female W-308 lasting 10-18 hours occurred after 16 June, and all were associated with prey carcasses. Upon her return to the den, she was frequently observed regurgitating to her pups. Similarly for other adults and yearlings, all excursions involving freshly killed ungulate carcasses exceeded 12 hours.

There were differences between the alpha females on dates and duration of excursions. Susitna female S-295 was away from the den for > 10-hour periods after 19 May (pups 19 days old) but none of the excursions exceeded 12 hours. In contrast, the Watana female did not leave for > 10 hours until after 17 June (pups 36 days old), and none exceeded 18 hours but all involved kill sites.

Based upon time away from the den and observations of the alpha female regurgitating food to pups, the Susitna female appeared to be a more active participant than the Watana female in obtaining food for pups. We speculate that this was a function of pack size, experience, and structure (Harrington et al. 1983; Ballard et al. 1987: 23). If the Susitna female had been monitored daily from fixed-wing aircraft like the Watana pack, we suspect her longer duration excursions would have been related to fresh ungulate kills.

Attendance near dens by subordinate pack members was highly variable. Overall, yearling males spent less time at the den and were absent longer than yearling females ($t = -4.748$, $P < 0.001$). Two female yearlings, W-324 and W-346, spent 40% of their time at the den. Both wolves were timid, submitting to all members of the pack. They also tried to nurse and beg food from other wolves returning to the den. Sixty-seven percent of W-346's absences were less than nine hours, and she was the only wolf other than the alpha female whose absences from the den never exceeded 31 hours. Wolves W-324 and W-346 averaged 9.1 and 9.5 hours per day near the den, respectively (Table 1), but W-346 was present daily while wolf W-324 was away from the den site on at least five occasions for >24 hour periods (Table 2). Long absences from the den typically were associated with activity at prey carcasses.

Although yearling females W-324 and W-346 spent nearly equal amounts of time at the den (Table 1), when only one yearling was present it was W-324 78% of the time. We suggest that the greater amount of den attendance by W-324 and W-346 was primarily selfish and contributed little to pup survival. These smaller, less aggressive wolves may have been spending proportionately more time at the den because they were obtaining food from other pack members by begging (Harrington et al. 1983). Den attendance by the other yearlings was highly variable and their roles concerning pup survival are not fully understood.

TABLE 2. Frequency of duration of absences by individual wolves from two den sites during May and June 1980 and 1981 in southcentral Alaska as determined by electronic monitoring of radio signals.

			Duration of excursion (h)			
Pack name	ID no.	Age - sex	1-2	3-9	10-30	31+
Susitna	295	Adult-female	5	10	4	-
	305	Adult-male	2	3	-	7
Watana	308	Adult-female	10	9	3[a]	-
	324	Yrlg-female	4	10	15	6
	325	Yrlg-male	7	7	16	6
	345	Yrlg-male	5	5	7	4
	346	Yrlg-female	16	24	12	0

[a] All three excursions occurred after 16 June 1981.

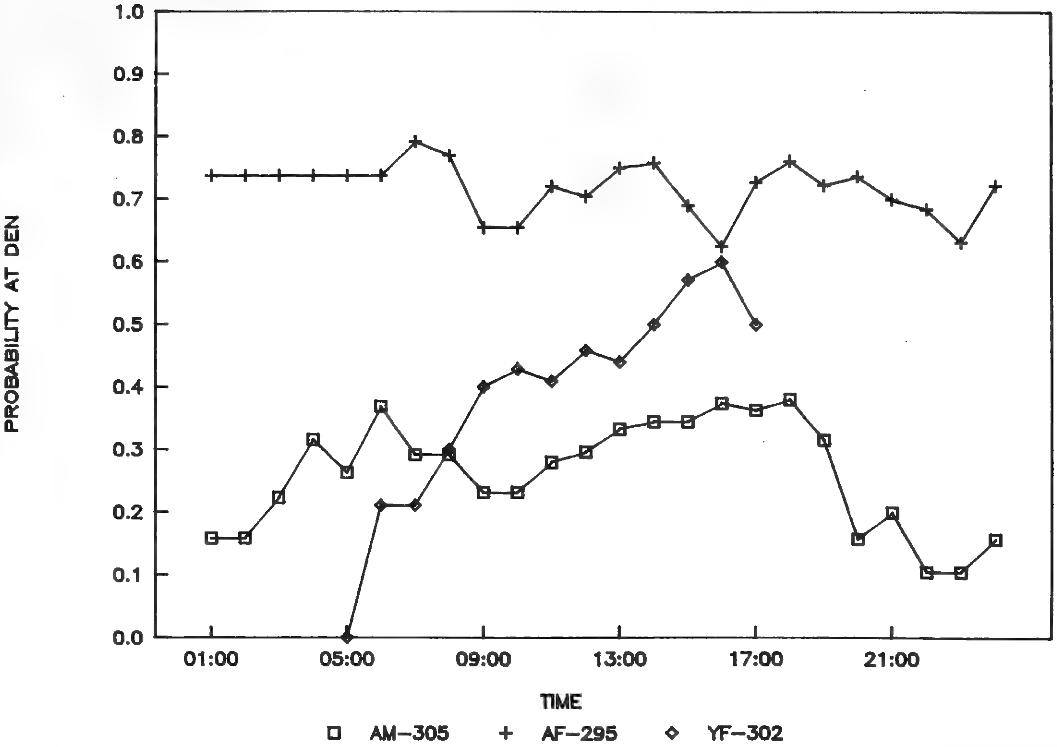

FIGURE 1. Probability of finding individual radio-collared wolves on an hourly basis at the Susitna wolf den as determined from continuous monitoring of radio signals from 20 May through 7 June 1980 in southcentral Alaska (AM = adult male, YM = yearling male, and AF = adult female).

There were 63 possible combinations of association for the six radio-collared wolves at the Watana den site but only 41 were observed. Absences from the den site usually involved male yearlings W-345 and W-325 (Table 2).

Harrington and Mech (1982) reported that den-site attendance by yearlings differed from other pack members. Their yearling males tended to stay away from homesites until after parturition. One of our yearling males (W-345) exhibited the pattern of attendance they described. This wolf left the pack area with two other wolves prior to parturition and returned to the den three weeks after parturition in early June. In comparison, yearling male W-325 spent more time near the den prior to and for one week following parturition. W-325 was submissive to all other males in the pack and most of his absences from the den were of short duration in the accompaniment of W-324.

There were no significant differences ($P > 0.05$) in arrival and departure times for alpha female S-295, but the frequency of such activity appeared more numerous in afternoon and early evening hours (50% of 40 observations between 1300 and 2000 hours). Alpha male S-305 exhibited a tendency to leave the den site between 1700-2000 hours (50% of 14 observations) and return between 0500-1200 (73% of 11 observations). After departure from the den, he usually remained away for 30-36 hours. There were no distinct patterns of arrival or departure times for individual Watana pack members. When individuals were pooled, however, there was a tendency for departure between 2100 and 2400 hours (27% of 191 observations) and arrival between 2100 and 0400 hours (51% of 174 observations). Arrival and departure times observed in this study were comparable to those reported by Kolenosky and Johnston (1967) in Ontario. In our study, wolves were most active at the den between 0600 and 0800 and 2100 and 2300 hours. Arrivals and departures occurred least frequently during 1300-2000 hours.

Because of the larger number of wolves present in the Watana pack, we expected overall activity to be higher at the Watana den than at the Susitna den. Overall, activity was twice as great as that recorded for the Susitna pack, but this difference was not significant ($t' = 1.17$, df = 5, $P = 0.30$).

The Watana alpha female (W-308) was the most active (8.9 hours/day pre-weaning and 9.2 hours/day post-weaning) of any of the wolves studied (Table

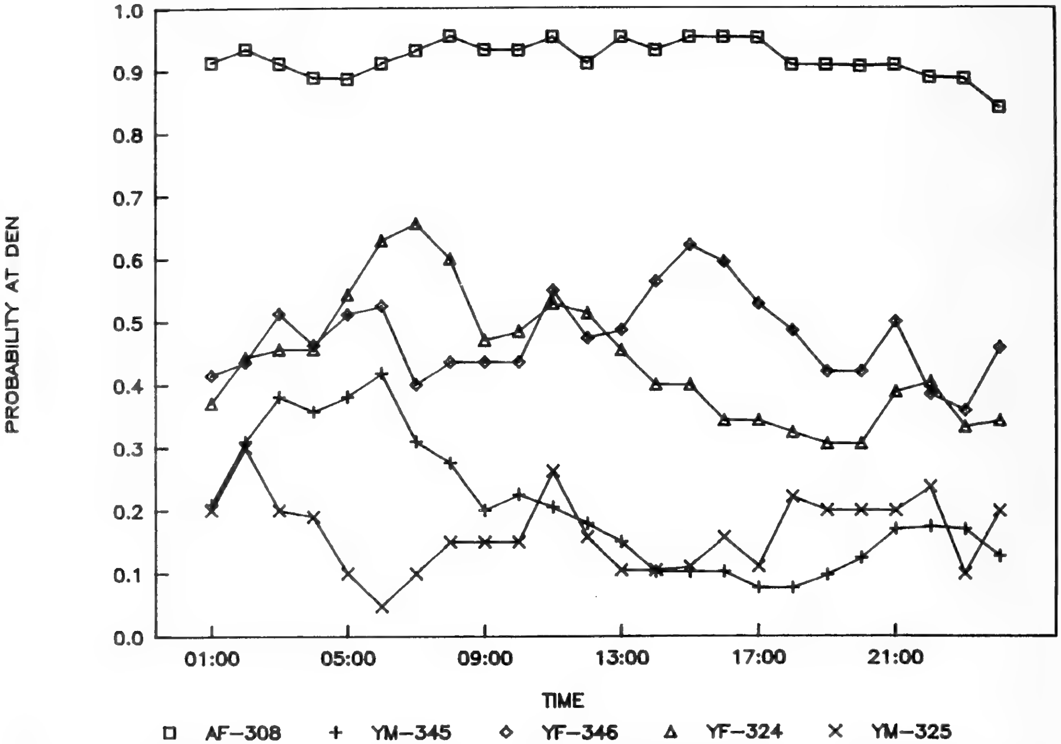

FIGURE 2. Probability of finding individual radio-collared wolves on an hourly basis at the Watana wolf den as determined from continuous monitoring of radio signals from 8 May through 21 June 1981 in southcentral Alaska (AM = adult male, AF = adult female, YF = yearling female, and YM = yearling male).

1). She was active more than 13 hours on 8 days and was never less active than 4 hours per day. On days she was relatively inactive (< 9 continuous hours/day), wolves W-324, W-325, or W-346 were present and were active 10-16 hours per day. In comparison, the Susitna alpha female (S-295) was active for > 7 hours on only 1 of 16 days and was active less than 4 hours on 8 days. Wolf S-295's absences from the den averaged 1 hour/day more than those of Watana female W-308, but she rested significantly more than the Watana female ($t = 4.258$, $P < 0.001$).

Harrington and Mech (1982) concluded that groups of wolves most likely would be found at dens near dawn, less frequently at dusk, and few would occur during the day (about 0800 to 2000 hours). Alpha females in our study had higher probabilities of being found at dens during all hours than other sex and age classes of wolves (Figures 1 and 2). Yearling females had the second highest probability of being found at den sites followed by yearling males, but probabilities of specific hours of attendance or absence were variable and not predictable.

In contrast to Harrington and Mech's (1982) findings, there was a relatively high probability that groups of wolves could be found at the den during the day. We concur with Harrington and Mech (1982) that some of these reported differences may be related to different lighting conditions in Alaska. During the denning season in Alaska, there are no periods of complete darkness, and, although prey may be more active during crepuscular hours, the differences may not be as pronounced as farther south. Also, because the Minnesota population was food stressed, wolves in that area may have been forced to hunt during all daylight hours (Harrington and Mech 1982).

Even though not the sire of the pups, Susitna male S-305 appeared to be the primary food provider because he was responsible for three of the four known ungulate kills and he was absent from the den more than other wolves. Susitna male S-305 was absent from the den site from 31 to 37 hours every 2.5 days. No other wolves in either pack were absent from the den as much. Based upon aerial observations we surmised that S-305's absences from the den were related to extended hunting forays. We expected a similar pattern of den attendance for the alpha male from the Watana pack but he was not radio-collared. Groups of yearling wolves appear to be largely unsuccessful at killing large ungulate prey

without the leadership of more experienced adults, particularly alpha males (Ballard et al. 1987: 23). Therefore, pack age structure appears to be important in determining the type, sex, and age of prey and perhaps the frequency of ungulate kills. The attendance pattern of alpha male S-305 fit the general pattern described by Harrington and Mech (1982) except that S-305 was present at the den more often and on a more regular basis than those in Minnesota, perhaps reflecting greater prey availability in the Alaskan study.

Strip-chart and ground observations suggested that when pups were 2 to 7 weeks of age they were left alone at the den about 15% of the time. However, yearling female S-306 was not monitored by either strip-chart or ground scanning. All monitored yearlings from both packs were observed alone at the den. Therefore, 15% was the maximum time pups were left unattended at the Susitna den. Pups were left unattended at the Watana den about 5% of the time in 1981.

Harrington and Mech (1982) and Chapman (1977) reported that pups were frequently left unattended for long periods. Chapman (1977) reported that in three Alaskan packs, pups were left unattended from 40 to 73% of the time depending on pack size and composition. In contrast, our data indicate that packs numbering 4 to 8 adults inhabiting areas of plentiful food resources seldom left pups unattended. The duration and frequency that pups are left unattended at dens appears highly variable among areas and may depend on a number of factors including age of pups, available food resources, and sex and age composition of the pack. Measurement of potential causative factors is required before any conclusions can be made.

The death of the Susitna alpha male and a large yearling male prior to denning allowed us to study possible impacts of losses of key individuals on denning behavior and pup survival. Although both Peterson et al. (1984) and Ballard et al. (1987) found no significant relationship between number of surviving pups and numbers of adults in packs, it seems reasonable that quality and quantity of food delivered to the den is related to pack size and age structure in some manner. However, identification of the threshold level at which survival is influenced has not been determined. Packs composed of several adults would not require the assistance of alpha females in killing large prey. Such females could provide continuous care to pups rather than leaving at regular intervals. Packs composed of only one adult may not be able to provide optimal quantities or quality of food without the assistance of the alpha female. Ballard et al. (1981) report one case where a single adult female successfully raised 3 to 4 pups. This litter size was less than the average of 5.3 reported by Ballard et al. (1987) and was near the 1975 average of 3.7 when the density of ungulate prey was lowest. In our study both packs of 4 and 8 adult wolves each successfully raised litters of 6 pups. Neither pack left the den unattended for long periods as was found in areas of lower food resources (Harrington and Mech 1982; Chapman 1977). In smaller packs it appears that alpha females must take a more active role in obtaining prey compared to packs with more adult wolves if length of time away from the den means more time hunting. Also with smaller packs, there was less den attendance by yearlings. If subordinate yearlings are not as capable hunters as adults (Ballard et al. 1987), then perhaps in relatively large packs yearlings may spend more time at the den begging excess food (Harrington et al. 1983). There may be a shortage of excess food in smaller packs accounting for lower attendance rates by yearlings at den sites.

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Effect of Peat Extraction on the Vegetation in Wainfleet Bog, Ontario

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Johnsson-Ninniss, Susan, and John Middleton. 1991. Effect of peat extraction on the vegetation in Wainfleet Bog, Ontario. Canadian Field-Naturalist 105 (4): 505–511.

In order to measure the response of vegetation in Wainfleet Bog in southern Ontario to intense disturbance (total removal of vegetation and surface peat) associated with peat extraction, data were collected in each of four areas that had been regenerating for 1, 6, 10, and 24 years (3, 8, 12, and 26 years for tree data), as well as in a relatively less disturbed portion of the bog. Random plots were used to measure regrowth of vegetation in terms of mean height of vegetation, amount of bare substrate, number of plant species, similarity of species lists to the least disturbed area, and size and number of trees. Results indicate that the disturbed areas are regenerating quickly. However, the plots with regenerating vegetation differ from the relatively less disturbed plot in having a significantly higher density of woody vegetation and plant species lists that are 50% similar after 25 years of regeneration.

Key Words: Wainfleet Bog, Ontario, peat extraction, vegetation, disturbance, regeneration.

The present study was designed to investigate how commercial peat extraction has affected the Wainfleet Bog, a 1500 ha bog in the Regional Municipality of Niagara in southern Ontario, and specifically, whether the bog vegetation rebounds after disturbance. It was intended to have applied significance, in relation to conservation and management of Wainfleet Bog, and to contribute to understanding of the ecology of peatlands in Canada. "Despite the abundance of organic terrain in Canada,... comparatively little research has been directed towards the comprehension of the physical and biological processes within these systems" (Bartsch and Moore, 1985).

Bogs are rare in southern Ontario where at least 50% of the natural wetlands, including bogs, have been converted to other uses. The figure reaches 80% for the Niagara peninsula, and 90% for southwestern Ontario (Environment Canada 1986). Wainfleet Bog is one of the most important of the remaining bogs in Ontario south of the Canadian Shield (Regional Municipality of Niagara 1985), and is the most southerly bog of its size in Canada. More than one-third has been lost to peat extraction and agricultural activities, yet this area accommodates provincially rare species such as the Massasauga rattlesnake (*Sistrurus catenatus*; personal observations; LeRay 1930; Ontario Ministry of Natural Resources 1989).

This bog offers an excellent opportunity to study the regeneration of an ecosystem over a long period of time. Parts of the bog have been mined for peat, while other parts have been left relatively less disturbed. Using aerial photographs and maps, the history of disturbance and time since regeneration began have been determined for each area. Thus, the extent and rate of the ecosystem's subsequent regeneration can be measured, and evaluated with reference to an internal control.

Study Area

The Wainfleet Bog, situated near the towns of Port Colborne and Welland in southern Ontario (Figure 1), is a 1500 ha bog, with peripheral areas of fen, marsh, and swamp forest (Environment Canada 1986). It is by far the largest of the Class 1 wetlands in the Niagara Region, the highest rating according to the classification scheme of the Ministry of Natural Resources (Ontario Ministry of Natural Resources 1984a, 1984b). In recognition of its significance, over 200 ha of the least-disturbed parts of Wainfleet Bog are designated as an Area of Natural and Scientific Interest (ANSI), and were purchased on behalf of the Government of Ontario in 1988.

It lies at elevations between 175.5 and 178.5 metres on the Haldimand Clay Plain at a latitude of 42°55'N and longitude of 79°17'W. The bog has an east-west length of approximately 5 km and a north-south expanse of approximately 3.5 km. It is bordered entirely by drainage ditches and roads. Parts of the periphery of the historical area of the bog have been permanently converted to agricultural, industrial, and other uses.

The bog is relatively young and shallow. The maximum depth of the peat is 5 m, and at most points it is less than 3 m deep. Preliminary coring and ^{14}C dating of the lowermost organic stratum give a date of approximately 5000 B.P. Many large stumps throughout the bog indicate that the bog itself

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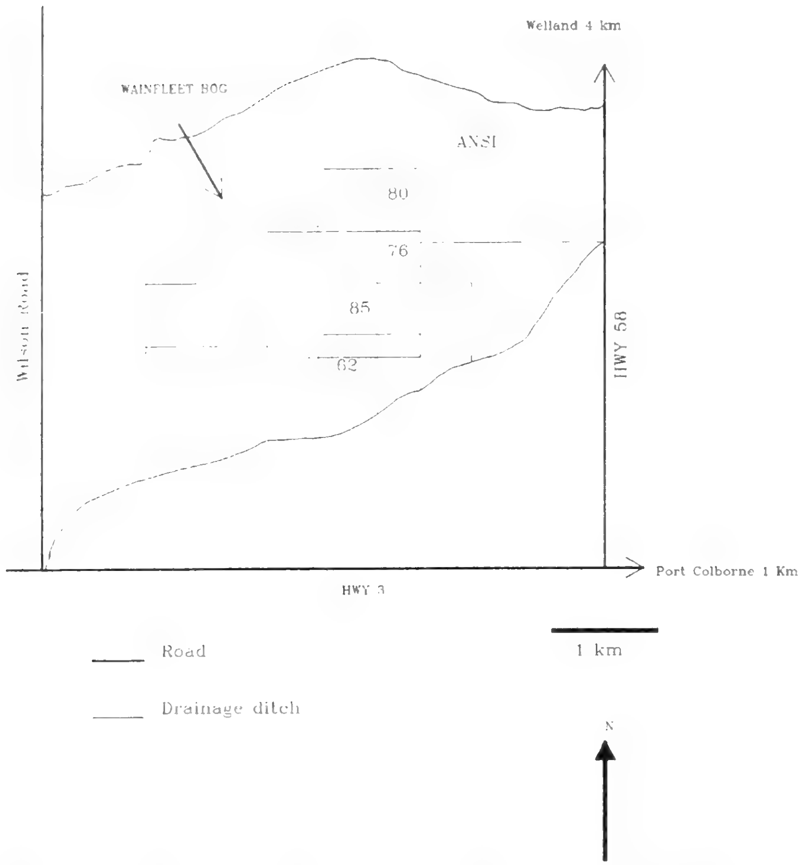

FIGURE 1. Schematic map of Wainfleet Bog (not strictly to scale). Labels (85, 80, 76, 62, ANSI) show location of disturbance plots.

did not begin to develop and replace the pre-existing forest until an even more recent date (C. Donaldson, Brock University, unpublished data).

The peat extraction process begins with complete clearance of all living vegetation. The exposed surface of the organic substrate is allowed to dry. The dry, loose peat is then removed from the surface with large vacuum machines pulled by tracked crawlers during the summer. The peat is of relatively low commercial quality with short fibres and dust-like characteristics. A major impediment to peat extraction is the large number of stumps and branches from the forest that occupied the site before the bog developed. Modern heavy machinery is used to a certain extent to remove the woody debris and so give access to more peat, but technical and especially economic constraints are severe. This woody debris generally limits harvesting to the uppermost 2 m of peat. After the easily accessible peat has been removed, the mined plot is abandoned to natural regeneration.

The bog has been altered by interior levelling in the peat extraction process. There is very little open water, with the exception of the artificial drainage channels which entirely ring the bog, and form a grid within the mined areas. There are no drainage channels within the least-disturbed portion of the bog. The present state and variability of the water table in various parts of the bog are described below.

Trembling Aspen (*Populus tremuloides*) and birch (*Betula* spp.) form an almost impenetrable forest margin between the interior of the bog and surrounding farmland, broken only by two access roads to the mined areas. The relatively less disturbed portions of the bog are predominately open with scattered trees (*Betula* spp.) and almost complete ground cover of *Sphagnum* mosses and ericacious shrubs. The mined portion of the bog varies from bare peat (without living vegetation), to shrubland, to thick bush with a partially closed canopy. Species lists are presented below.

Methods

Sets of aerial photographs were studied and examinations were made on foot to establish locations of

plots in the mined area of the bog that have been regenerating for different lengths of time. Mined and regenerating plots are clearly visible on these photographs. The year of abandonment was established for each plot by cross-checking aerial photographs with records of the mining company.

The plots used were areas abandoned to regeneration in 1962, 1976, 1980, and 1985, after the mining operation had removed all vegetation and up to two metres of peat. The study plots thus represent 1, 6, 10, and 24 years of natural, unassisted regeneration for ground vegetation (data collected in 1986) and 3, 8, 12, and 26 years for trees (data collected in 1988). One area not directly disturbed by the mining operation was also examined, as a comparison. This so-called ANSI portion of the bog (Area of Natural and Scientific Interest) is more similar to what the mined areas of the bog were like originally than are the mined plots (Ontario Ministry of Natural Resources 1987). These five areas will be referred to as disturbance classes below. Each disturbance class is a rectangular area of at least 5 ha with the shorter dimension being at least 100 m.

The mining process concentrates on one part of the bog at a time, and so does not produce replicate disturbance plots. Statistical analysis involved replication with random quadrats within each disturbance class ($n = 20$ for each disturbance class, 100 quadrats in total), and analysis of the time series ($n=5$ disturbance classes, including ANSI).

The following system was used for sampling ground vegetation. A random compass bearing and a random distance in metres were used to arrive at each quadrat in each disturbance plot. Each sampling quadrat was 1 m by 5 m (subdivided into 25 sections of 0.2 m by 1 m each, to allow more accurate estimation of ground cover). Twenty quadrats were sampled in each area beginning in June 1986 and finishing in mid-November 1986. Maximum height and percentage of ground coverage (including the category "Bare Substrate" where there is no living vegetation) were recorded for each species in each quadrat. Unknown plants (including grasses, sedges and mosses) were collected directly in the field, placed in a press or bottled, and sent to be identified by taxonomic specialists. Vascular plant names follow Scoggan (1978); mosses follow Ireland and Bellolio-Trucco (1987).

Trees were sampled with larger quadrats of 10 by 20 m. Twenty tree quadrats were chosen in each disturbance class using random compass bearings and random distances. The species and diameter at breast height (dbh) were recorded for each tree in each quadrat. Trees were sampled in 1988.

Height of the water table was measured in different parts of the bog by digging test holes of radius 20 cm vertically down through the peat. Surveyed elevations above sea level are available for some but not all of the test holes (since some areas of the bog are very difficult to access with surveying equipment). Thus results were recorded in the less precise but more repeatable measure of depth of water table below surface.

It is assumed throughout the analysis that the disturbance classes are identical except for their disturbance histories. All plots share the same substrate, water regime, climate, freedom from other human disturbances, and access to the regional species pool. All plots were within a radius of 2 km, on organic peat, on flat surfaces differing in elevation by no more than 3 m, and in the same drainage system.

Similarity of species lists for different disturbance plots was determined using the coefficient of community (Pielou 1974),

TABLE 1. Relationship of major variables of plant growth to length of regeneration.

Disturbance class:	1985	1980	1976	1962	ANSI
Years of regeneration**	1	6	10	24	*
Mean Proportion of Bare Substrate	0.97	0.61	0.35	0.14	0.005
Mean Height (cm)	3.6	17.0 a	15.8 a	26.4 b	26.9 b
Mean number of species per quadrat	6.9	15.8 c	11.4 d	15.3 c	11.7 d
Mean number of trees per quadrat	0 e	4.2	7.1	10.2	1.2 e
Mean DBH of trees (cm)	0	2.6 f	4.2 f	3.4 f	4.4 f

*ANSI (Area of Natural and Scientific Interest) is the relatively less disturbed control.
**3, 8, 12, and 26 years for tree data.
NOTES: Values marked with the same letter are not significantly different from each other (SNK test, $p < 0.05$). There is a significant effect of disturbance class on each of the vegetation variables (one-way ANOVA, $p < 0.01$). N = 20 for each cell.

TABLE 2. Species lists for each disturbance class.

Species	1985	1980	1976	1962	ANSI
Agrostis hyemalis	+	+	+	+	+
Apocynum androsaemifolium		+			
Aralia hispida		+			
Aronia melanocarpa			+	+	+
Bartonia virginica		+		+	
Betula papyrifera	+	+	+	+	+
Betula pendula	+				
Betula populifolia	+	+	+	+	+
Betula sandbergii	+	+	+	+	
Bidens cernua	+	+			
Bidens coronata	+	+	+	+	
Calamagrostis canadensis				+	
Campanula uliginosa		+			
Carex comosa	+	+	+	+	+
Carex trisperma					+
Chamaedaphne calyculata		+	+	+	+
Chrysanthemum leucanthemum		+			
Drosera rotundifolia				+	
Dryopteris spinulosa		+			+
Eleocharis acicularis				+	
Epilobium angustifolium					+
Equisetum arvense		+		+	
Eriophorum virginicum	+	+	+	+	+
Glyceria striata	+	+	+	+	
Hieracium aurantiacum		+	+		
Hypericum canadense				+	
Hypericum virginicum		+	+	+	
Juncus canadensis	+	+	+	+	
Juncus effusus	+	+	+	+	
Kalmia angustifolia	+	+	+	+	+
Kalmia polifolia					+
Lactuca scariola		+			
Ledum groenlandicum				+	+
Linaria canadensis		+			
Lycopodium clavatum			+	+	+
Lycopus uniflorus	+	+	+	+	
Muhlenbergia mexicana	+		+		
Onoclea sensibilis					+
Osmunda cinnamomea	+	+	+	+	
Panicum sp.			+	+	
Phragmites communis				+	+
Pohlia nutans		+	+	+	+
Polytrichum strictum	+	+	+	+	+
Populus tremuloides	+	+	+	+	+
Prunus virginiana			+	+	
Quercus rubra		+			
Rubus allegheniensis			+	+	
Rubus hispidus	+	+	+	+	
Rubus occidentalis		+		+	
Rumex acetosella	+	+	+		
Salix discolor		+			
Salix eriocephala	+	+	+	+	
Salix pyrifolia		+	+	+	
Scirpus cyperinus	+	+	+	+	+
Solidago sp.	+	+	+	+	+
Sphagnum capillifolium					+
Sphagnum fimbriatum					+
Sphagnum papillosum			+	+	+
Spiraea alba		+		+	
Stellaria longifolia	+	+		+	
Vaccinium angustifolium		+	+		+
Vaccinium corymbosum	+	+	+	+	+
Vaccinium oxycoccus				+	+
Viola lanceolata		+	+	+	
Zanthoxylum americanum			+		

$$CC = 200\, S_{xy}/(S_x + S_y)$$

where S_x and S_y are the number of species in the two areas being compared, and S_{xy} is the number of species shared by the two areas.

Other analyses were done with the Practical Statistics statistical package (deCatanzaro 1988). Significance of trends through the time series (n = 5 disturbance classes, including ANSI) was assessed with one-way analysis of variance (ANOVA) with 20 replicates per cell (20 quadrats per disturbance class). Significance of pair-wise comparisons of means was assessed with the Student-Newman-Keuls test.

Results

The trend of major variables with time as regeneration proceeds is summarized in Table 1. The change in each variable is statistically significant (ANOVA, $p < 0.01$), although not all trends are monotonic.

The amount of bare substrate drops off precipitously within the first years, with a significantly lower amount of bare substrate found in each subsequent disturbance class. The substrate is 90% covered by living vegetation after 24 years, and over 99% covered in the relatively less disturbed ANSI.

The mean height of the canopy, excluding trees, increases with time. After 24 years of regeneration, the mean height is not significantly different from the relatively less disturbed ANSI.

The area of latest abandonment, 1985, has a significantly lower number of plant species than any other disturbance class. The number of plant species increases rapidly and exceeds the number in the less disturbed ANSI area after only six years of regeneration. There is no significant trend thereafter.

The number of trees per unit area increases with time. However, the less disturbed ANSI seems to fall outside the sequence of the regenerating plots, having significantly fewer trees per unit area than any other disturbance class except 1985, which had been regenerating for only three years when these data were collected. By contrast, the trend in mean size of trees (dbh) is approximately monotonic, with the largest mean size in the less disturbed ANSI. However, there are no statistically significant differences in mean size after the first eight years of regeneration, and the means are all small.

Data based on species lists are summarized in Tables 2 and 3. In the older plots, the vegetative community becomes more similar to the less disturbed ANSI. The coefficient of community shows that the species lists are 50.8% similar after 24 years of regeneration.

Data on the depth of the water table in five replicate holes in three different disturbance classes (1980, 1976, ANSI) were taken in June 1988 during the most prolonged drought on record. No measurable rain fell during the sampling period. The water table in holes in the less-disturbed ANSI was between 20 and 40 cm deep, as compared to 40 to 70 cm deep in the disturbed plots. Values from the less disturbed ANSI were distinct from those of the regenerating plots on each sampling date, with no overlap in range of values.

Discussion

No part of the bog can be called "undisturbed". All parts of the bog, including the ANSI, have been affected by changes in drainage, in fire frequency, in atmospheric pollution, and probably other factors as well. The birches (*Betula* spp.) are invading, while there is now no trace of species such as Pitcher Plant (*Sarracenia purpurea*) and Black Spruce (*Picea mariana*) which anecdotal information suggests were part of the vegetation in previous decades. All comparisons in this study are between more and less disturbed portions of the existing bog. Extrapolation to the "original" state of the bog in previous decades or centuries must be made with great care.

The peat extraction operation creates a very severe disturbance. All vegetation is removed, followed by up to two metres of peat. After the peat is extracted, and the plot is abandoned by the mining company, regeneration begins, unaided by human intervention, on a completely bare substrate of relatively homogeneous dead organic matter.

Despite the severity of the disturbance, regrowth of vegetation begins within a year. Within ten years there are more species, of a higher stature, than before the mining began, and the amount of bare substrate has dropped off to a low level (Table 1). Thus, the bog ecosystem clearly does not remain as an abiotic wasteland after disturbance; it rebounds at an impressive rate. This is consistent with results from other parts of the world (Elling and Knighton 1984; Nick 1984, 1985) which find that regeneration of some sort occurs with or without direct human intervention.

The water table remained higher in the less disturbed ANSI than in the regenerating plots despite the prolonged drought during the sampling period. The high water table in an intact bog reflects primarily slow drainage of rain water applied from above,

TABLE 3. Coefficient of Community (C.C.)* for each pair of species lists.

1980	56.7			
1976	69.2	71.4		
1962	54.2	64.9	75.4	
ANSI	33.3	33.3	42.3	50.8
	1985	1980	1976	1962

*C.C. is an estimate of percent similarity of species lists; higher values indicate greater similarity.

rather than capillary movement from below (Damman 1986). The much higher water table in the less disturbed ANSI as compared to the regenerating plots illustrates the hydrological effect of an undisturbed bog, an effect which is often cited in support of wetland conservation. For example, Winkler and deWitt (1985) summarize evidence showing that the hydrological impacts of peat extraction may be extensive, and conclude "it is clear that these ecosystems are far more valuable to society when they are left undisturbed".

Tables 2 and 3 show that species lists for the disturbed plots become increasingly similar to that of the less disturbed bog for at least the first twenty-four years of regeneration (which is as far as our data go). The plot abandoned to regeneration in 1962 has 50.8% similarity in plant species to the ANSI (based on presence/absence data only). The shared species include such typical bog species as blueberry (*Vaccinium corymbosum*), Cranberry (*Vaccinium oxycoccus*), Labrador Tea (*Ledum groenlandicum*), Leatherleaf (*Chamaedaphne calyculata*), and peat mosses (including *Sphagnum papillosum* and *Sphagnum capillifolium*). Thus these data suggest that the mined plots are regenerating in the direction of the state of the less disturbed ANSI. In the younger plots, the typical bog species are found in small numbers, thus comparisons that took into account abundance and not just presence or absence would show a smaller degree of similarity.

The regrowth of *Sphagnum* may be particularly significant, as these peat mosses dominate the autogenic succession of bog ecosystems (Luken and Billings 1985; Glaser and Janssens 1986; Payette 1988). *Sphagnum* has a remarkable ability to regenerate, even from apparently dead specimens buried for tens of years below the water table (Clymo and Duckett 1986), but can do so only if hydrological and other conditions remain suitable.

The fact that there are more species in some of the regenerating plots than in the less disturbed ANSI is not necessarily anomalous. This is a common observation in many kinds of ecosystems, and forms the basis for the widely accepted Intermediate Disturbance Hypothesis (Huston 1979; Connell 1978; Middleton and Merriam 1985; Grime 1979). Giller and Wheeler (1986) found the same pattern in disturbed peatlands of England (although they were dealing with a minerotrophic fen rather than an ombrotrophic bog): "the species-rich communities are temporary seral phases which probably gradually develop into vegetation similar to that of uncut peat surfaces".

However, the fact that there are trees up to 5 m high after a short period of regeneration while there are few in much of the ANSI, is a more problematical observation. It is possible that the trees we observe in the regenerating plots indicate a change in direction of succession away from that which led to the original state of the bog.

Watt (1947) recognised that the later stages in a successional process may be of lower stature than some earlier stages. Various studies have shown this to occur also in bogs, with trees being eliminated by sphagnum as the bog ages (Glaser and Janssens 1986; Payette 1988). The smaller number of trees in the less disturbed ANSI may thus reflect a process of autogenic succession towards an open bog. However, elsewhere in eastern North America, the decrease in tree cover is associated with an increase in the amount of open water (Glaser and Janssens 1986), a pattern not found in Wainfleet.

Treed bogs are common in eastern North America (Grigal 1985; Grigal, Buttleman, and Kernik 1985; Glaser and Janssens 1986; Payette 1988). However the typical treed bogs involve species of *Larix* and *Picea*, not the *Betula* and *Populus* which dominate in Wainfleet. Furthermore, one of the trees found in the regenerating plots is *Betula pendula*, an exotic species not part of the system that existed before mining began. It is definitely a recent invader, and further suggests that the other trees are recent invaders as well.

We conclude that, although large parts of Wainfleet Bog have been severely disturbed, regeneration is rapid, in terms of amount of bare substrate, mean height of vegetation, and number and type of plant species. However, the pattern of growth of trees in various parts of the bog indicates that the direction of regeneration is not strictly towards the original condition of the bog before mining began.

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Status of False Rue-anemone, *Isopyrum biternatum* (Ranunculaceae), in Canada*

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False Rue-anemone (*Isopyrum biternatum*) is a spring-flowering perennial herb distributed from southern Ontario to Minnesota, south to Florida and Texas. In Canada, extant populations are known only from the St. Thomas — Port Stanley area in Elgin County, the London area in Middlesex County, and near Arkona in Lambton County. *Isopyrum biternatum* is considered vulnerable in Canada due to the relatively specialized wooded floodplain habitat that it requires and its restricted range in the Carolinian zone of Ontario.

Key Words: *Isopyrum biternatum*, False Rue-anemone, Ontario, vulnerable, habitat, distribution, population size.

False Rue-anemone, *Isopyrum biternatum* (Raf.) T. & G. has a limited distribution in Canada, only occurring in southern Ontario. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was interested in determining the current status of this species in Canada. Therefore, the author conducted field work during April — June, 1988 to determine the location and number of *I. biternatum* populations in Ontario.

Isopyrum biternatum is an erect, perennial herb (Figure 1) found in woodlands with moist, rich calcareous soils. Plants grow to a height of 10-40 cm. Stems are ribbed, glabrous and originate from a tuberous rootstalk. Basal leaves are usually biternate with long petioles. Stem leaves are short petioled or sessile and biternate; occasionally the uppermost stem leaves are triternate. Leaflets are usually 2-3 lobed and glabrous, with shallow to deep sinuses. *Isopyrum biternatum* is apetalous, the flower being comprised of five white, round-tipped sepals and born singly, either in an axillary or terminal position. Flowers are bisexual. Mitchell and Dean (1982) provide a good technical description of *Isopyrum biternatum*.

Superficially, *Isopyrum biternatum* resembles Rue-anemone (*Anemonella thalictroides* (L.) Spach) in the division of its leaves and its delicate white flowers. However, *Isopyrum biternatum* has alternate leaves; divided leaves and deeply lobed leaflets; roots with scattered small tubers (Wherry 1948); and an erect stature. *Anemonella thalictroides* has whorled leaves, shallow-lobed leaves, a cluster of tubers, and a low-growing stature. *Isopyrum biternatum* may be easily overlooked in the field due to its early flowering time and its resemblance to *Anemonella thalictroides*. *Isopyrum biternatum* could also be confused with *Thalictrum* spp., particularly Early Meadow-rue (*Thalictrum dioicum* L.), on the basis of vegetative characters. *Isopyrum biternatum* has more deeply lobed leaflets, a slightly reddish stem (in Ontario populations at least), brighter green leaves and a different flower structure.

Distribution

The distribution of *Isopyrum biternatum* in North America, shown in Figure 2, is based on herbarium records from Ontario and the United States (herbaria consulted are listed in the COSEWIC status report). *Isopyrum biternatum* occurs from southern Ontario to Minnesota, south to northeastern Texas, Arkansas, Alabama and northwestern Florida (Radford et al. 1965; Gleason 1968; Correll and Johnston 1970; McGregor and Barkley 1977; Mitchell and Dean 1982; Argus and White 1983). *I. biternatum* is recorded infrequently east of the Appalachian Mountains, but recent sightings in Virginia, North Carolina and South Carolina suggest that it may be more common than previously believed (Boufford and Massey 1976).

In Canada, the known distribution of *Isopyrum biternatum* is restricted to three counties in southwestern Ontario: Middlesex, Elgin and Lambton (Figure 2). Herbarium specimens indicate that *Isopyrum biternatum* was known to occur historically at several sites in Elgin County (Southwold and Yarmouth townships), Middlesex Co. (Williams Township), and Lambton Co. (Bosanquet and Stephen townships) Ontario; see COSEWIC status report by the author. Specimens of *Isopyrum biternatum* are found in the following Ontario herbaria: Department of Agriculture, Ottawa (DAO); University of Guelph, Guelph (OAC); University of Toronto (TRT);

*Based on a COSEWIC status report by the author. Copies of the complete report are available at cost from the Canadian Nature Federation, 453 Sussex Drive, Ottawa K1N 6Z4. Vulnerable status was approved and assigned by COSEWIC on 11 April 1990

FIGURE 1. Flower and foliage of False Rue-anemone (*Isopyrum biternatum*).

Erindale College (TRTE); and the University of Western Ontario (UWO). No recent records of *Isopyrum biternatum* have been reported in Norfolk County, suggesting that *I. biternatum* has been extirpated in its historical location near Lynn Valley east of Simcoe (Soper 1962). *Isopyrum biternatum* was not found during field investigations conducted near Parkhill (Middlesex County), Ontario in May 1989. A more intensive search effort in the Parkhill area may reveal a remnant population of *Isopyrum biternatum* in suitable habitat along Mud Creek.

Habitat

Throughout its range, *Isopyrum biternatum* grows in shaded woods and thickets, often on rich, wooded slopes in floodplain zones. This species is often found in close proximity to streams; Melampy and Hayworth (1980) found, respectively, 50% and 74% of 147 *I. biternatum* clumps within 10 and 25 m of streams in Illinois.

Populations of *Isopyrum biternatum* are restricted in Canada to the Carolinian Floral Region (Scoggan 1978). In Ontario, the species occurs in areas dominated by gray brown luvisolic soils which are rich in calcareous till and lacustrine deposits from limestone and dolostone (Hoffman 1989). *Isopyrum biternatum* is generally found in shady areas within mature maple-beech forests on gradual slopes; it is not found on steep slopes or in open, highly disturbed sites. Populations in Ontario were generally found in mixed hardwood Carolinean Forests, dominated by Sugar Maple (*Acer saccharum* Marsh.), in combination with other species including, Hop-hornbeam (*Ostrya virginiana* (Mill.) K. Koch), Blue-beech (*Carpinus caroliniana* Walt.), American Beech (*Fagus grandifolia* Ehrh.), Bitternut Hickory (*Carya cordiformis* (Wang.) K. Koch), Shagbark Hickory (*C. ovata* (Mill.) K. Koch), American Basswood (*Tilia americana* L.), Butternut (*Juglans cinerea* L.) and White Ash (*Fraxinus americana* L.). *Isopyrum biternatum* is found growing with Bloodroot (*Sanguinaria canadensis* L.), trilliums (*Trillium* spp.), Cut-leaved Toothwort (*Dentaria laciniata* Muhl.), Wood Anemone (*Anemone quinquefolia* L.), violets (*Viola* spp.), and Trout Lily (*Erythronium americanum* Ker.). *Isopyrum biternatum* has also been found in association with some rare plants in Ontario, including Virginia Bluebells (*Mertensia virginica* (L.) Pers.) and Green Dragon (*Arisaema dracontium* (L.) Schott) (Keddy 1984, 1987).

General Biology

Isopyrum biternatum is a hermaphrodite and grows in clumps that probably represent clones (Melampy and Hayworth 1980). *Isopyrum biternatum* is self compatible, but not autogamous; autogamy appears to be prevented by protogyny, with stigmas becoming non-receptive by the time the anthers dehisce (Melampy and Hayworth 1980).

Flowering begins when temperatures are suitable for plant growth and pollinator activity, and ends before closure of the canopy (Schemske et al. 1978). In Ontario and Illinois (Melampy and Hayworth 1980; Mitchell and Dean 1982), *Isopyrum biternatum* flowers in late April or May and is in fruit by early June. Flowering lasts 7-10 days; three to four days are spent in the female phase (Schemske et al. 1978). Delayed flowering peaks can be detrimental to seed set of *Isopyrum biternatum* (Schemske et al. 1978). In Ontario, seeds mature by late May/early June. Seeds have no known special means of dispersal (Schemske et al. 1978). Leaves begin to turn yellow or brown as seeds ripen, and by early to mid-June all have senesced (Baskin and Baskin 1986).

Isopyrum biternatum is pollinated by insects. No nocturnal pollinators were noted on *I. biternatum* (Melampy and Hayworth 1980); this is probably related to the cool nights during early spring when

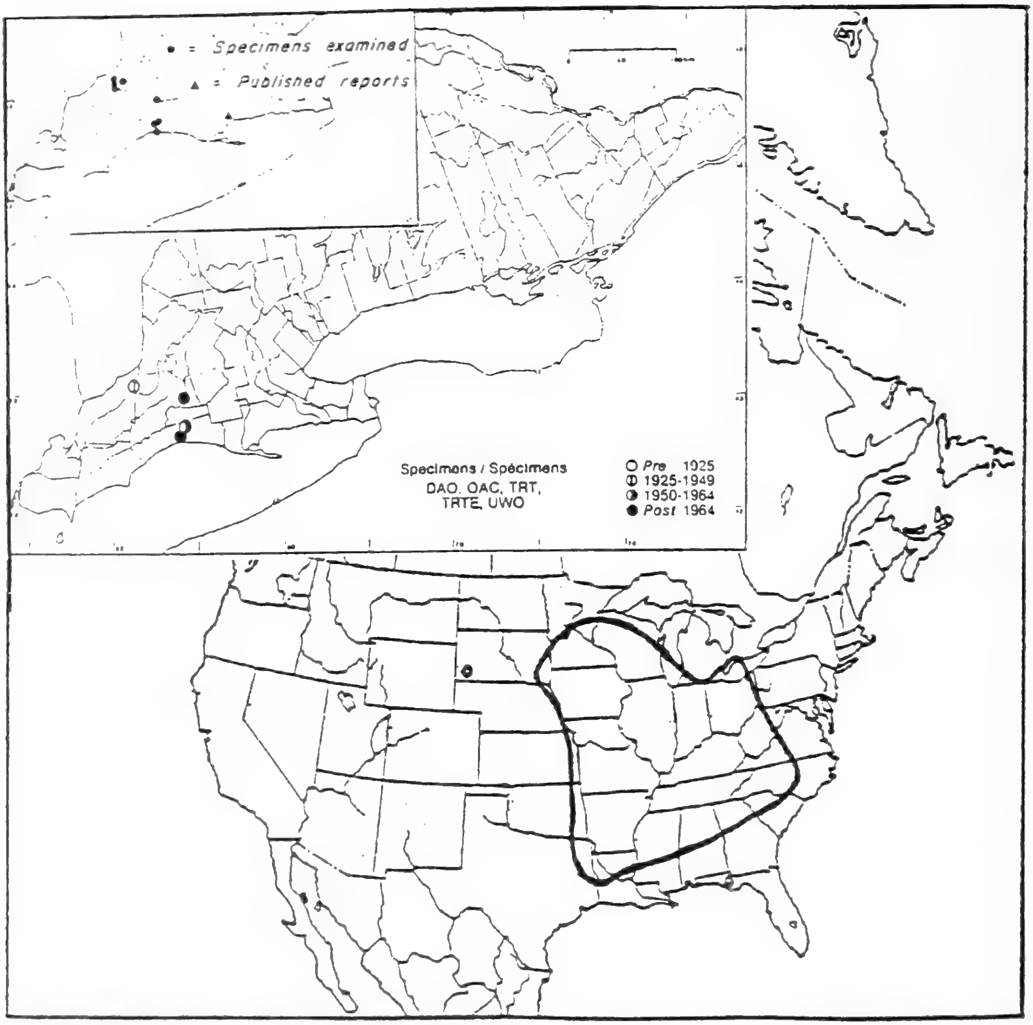

FIGURE 2. The distribution of False Rue-anemone (*Isopyrum biternatum*) in Ontario (insert) and North America. Ontario distribution taken from Argus and White (1983).

this species flowers. A variety of insects visit *I. biternatum* flowers (e.g., *Apis mellifera*, andrenid bees, halictid bees, syrphid flies, other flies, and beetles), however, the rate of visitation of these pollinators to *I. biternatum* plants is low, even when *I. biternatum* is in flower (Melampy and Hayworth 1980). *Isopyrum biternatum*, which is a nectarless plant, is not a preferred resource for insect pollinators when the nectar-bearing flowers of plants such as Spring Beauty (*Claytonia virginica* L.) and *Dentaria laciniata* are nearby (Melampy and Hayworth 1980). Nectarless plants, such as *I. biternatum*, may receive insect visits by extending their flowering season to include intervals when few nectar-producing plants are flowering (Melampy and Hayworth 1980). A shortage of pollinators could limit seed production in *Isopyrum biternatum* (Melampy and Hayworth 1980). Wind appears to play a minor role in the pollination of *Isopyrum biternatum* (Melampy and Hayworth 1980).

Embryos of *Isopyrum biternatum* are non-dormant and seeds of *I. biternatum* require a long time at high temperatures to complete embryo growth and germinate (Baskin and Baskin 1986). Laboratory studies suggest that exposing seeds of *I. biternatum* to high summer temperatures may enhance germination at early autumn temperatures (Baskin and Baskin 1986). Germination of *I. biternatum* is similar to that of species exhibiting epicotyl dormancy (i.e. radicles are dormant and require a period of warm stratification during the summer before they emerge at favourable autumn temperatures) because radicle

emergence occurs in the autumn. However, cotyledons also emerge from seeds of *I. biternatum* in autumn, whereas in species with epicotyl dormancy the seed with an emerged radicle must be cold stratified during the winter for the cotyledons to emerge (Baskin and Baskin 1986).

The germination pattern of *Isopyrum biternatum* differs from that of other perennial herbs of mesic deciduous forests studied to date (Baskin and Baskin 1986). Species of *Asarum*, *Caulophyllum*, *Cimicifuga*, *Erythronium*, *Hepatica*, *Hydrophyllum*, *Osmorhiza*, *Polygonatum*, *Sanguinaria*, *Smilacina*, *Stylophorum*, *Trillium* and *Uvularia* are deeply dormant and complete germination in the spring, whereas *Isopyrum biternatum* is non-dormant and completes germination in the autumn. All of these plants have underdeveloped embryos at seed maturity and dispersal (Baskin and Baskin 1986). Germination patterns have not been studied in Ontario populations of *Isopyrum biternatum*.

Isopyrum biternatum seedlings produced in the autumn have a much longer period for establishment and growth before the onset of dormancy in June, than if their germination were delayed until spring. Therefore, *Isopyrum biternatum* may require less time from seed dispersal to reproductive maturity than plants developing from seeds that germinate the following spring. It is not known whether there are any disadvantages to passing the winter in a seedling versus a seed stage (Baskin and Baskin 1986).

Population Size and Trends

Comprehensive studies have not been conducted on the demography, phenology and reproductive ecology of *Isopyrum biternatum* in Ontario. *Isopyrum biternatum* is a perennial with considerable vegetative propagation, and therefore, this may diminish to some extent the importance of high seed production in any one year (Schemske et al. 1978). Abundant seeds were produced by plants observed in Elgin County during early June. Populations in Ontario vary from small patches, less than 1 m X 1 m (approximately 50 plants), to very large patches with plants numbering in the thousands.

Twenty-one populations of *Isopyrum biternatum* are known from southwestern Ontario. Ten populations are found within a 15 km stretch of Kettle Creek and its tributaries between St. Thomas and Port Stanley (Elgin County). *Isopyrum biternatum* plants from these ten populations are estimated to number in the hundreds of thousands. The largest single population found by the author was located along the Elgin Trail, south of St. Thomas, Ontario. Two other populations are known from Yarmouth Township, Elgin County; these populations were not observed during a 1989 field study, but have been confirmed within the last five years (W. G. Stewart, personal communication).

Eight populations are known to occur along the Medway Creek near London (Middlesex County), Ontario. Other Medway Creek populations occur in the Arva area, Medway Heights, Huron College, and near the confluence of Snake and Medway Creeks. The latter population has scattered clumps of *I. biternatum* totalling approximately 500 000 to 700 000 plants; patches of plants ranged in size from 1 m^2-225 m^2. One small population, containing approximately 200 plants and covering an area of 3 m^2, was found at The University of Western Ontario, adjacent to the Thames River in May 1989. *I. biternatum* populations in this area appear to have been reduced due to the encroachment of Goutweed (*Aegopodium podagraria* L.) along this section of the Thames River.

Another population consisting of several scattered clumps of plants, and estimated to contain 2500-3000 plants, was found along the Ausable River, north of Rock Glen Conservation Area near Arkona (Lambton County), Ontario.

Limiting Factors

Isopyrum biternatum is found in floodplain habitats within the Carolinean Zone and has a restricted geographical range (Port Stanley, St. Thomas, London and Arkona) in Ontario. This species does not thrive in edge habitats or open areas, which now dominate the landscape of southwestern Ontario.

Many populations of *I. biternatum* are threatened by their proximity to public areas and trails. In these areas, plants are subject to spring wildflower-picking, soil compacting, and trampling due to recreational activities (e.g., hiking, cycling, camping, and recreational vehicles). Additional populations are threatened by the encroachment of other plants, such as *Aegopodium podagraria* and Garlic Mustard (*Alliaria officinalis* Andrz.), wood cutting practices, soil erosion, mowing, pesticide spraying and road salting.

Some populations of *Isopyrum biternatum* were found growing in conditions considered to be atypical for the species (e.g., adjacent to windfalls and tree cuts; in edge habitats; and among large growths of *Alliaria officinalis*, *Aegopodium podagraria*, or tall grasses). It is assumed that plant populations in these areas are on the decline, however, research is necessary to determine how seedling growth, seed output and germination in these populations differ from populations growing in more typical habitats.

Special Significance of the Species

I. biternatum is the only member of the genus represented in central and eastern North America; three other species of *Isopyrum* are native to the Pacific Coast of North America (Gleason 1968) and one species (*I. savilei* Calder & Taylor) is endemic to the Queen Charlotte Islands (Calder and Taylor 1963). *Isopyrum biternatum* has no known natural, medical or economic significance.

Protection

In the United States, *Isopyrum biternatum* is not considered federally endangered. However, it is considered rare in South Carolina, Virginia and Florida, and endangered in South Dakota (S. Maina, personal communication). In South Carolina, *Isopyrum biternatum* is known from only one location (Stevens Creek, Modoc, McCormick County), which is protected by South Carolina's Natural Heritage Program (S. R. Hill, personal communication). *Isopyrum biternatum* may now be extirpated in New York State; only a single pre-1840 specimen is known for New York (Mitchell and Dean 1982).

Evaluation of Status

Isopyrum biternatum is considered vulnerable in Canada due to the relatively specialized wooded floodplain habitat that this species requires, its restricted geographical range in the Carolinean Zone of Ontario, and the presence of the majority of known populations in public use areas. Several thousand *I. biternatum* plants can survive on small plots of land. Therefore, populations should survive in Ontario if floodplain areas along Kettle Creek, the Medway River, the Thames River, and Ausable River are preserved. Populations of *Isopyrum biternatum* found on conservation property may be protected from urban development, however, public access into these areas still poses a threat to these populations.

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Food Habits and Growth of Walleye, *Stizostedion vitreum*, Smallmouth Bass, *Micropterus dolomieui*, and Northern Pike, *Esox lucius*, in the Kaministiquia River, Ontario

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Food habits and growth rates were determined for Walleye (*Stizostedion vitreum*), Smallmouth Bass (*Micropterus dolomieui*) and Northern Pike (*Esox lucius*) from the Kaministiquia River near the City of Thunder Bay, northwestern Ontario in the summer of 1987. Adult Walleye were mainly piscivorous (90% by frequency) consuming large numbers of Johnny Darters (*Etheostoma nigrum*). Fishes most commonly eaten were those known to have a close association with the bottom. YOY Walleye were entirely piscivorous. Adult Smallmouth Bass consumed fish with high frequency (61%). However, total volume and weight of food consumed was dominated by crayfish. YOY Smallmouth Bass mainly ate insects. Adult Northern Pike were largely piscivorous (85% by frequency) consuming large numbers of White Suckers (*Catostomus commersoni*) reflecting close habitat association in shallow, weeded areas. Food habits of YOY Northern Pike mirrored those of adults. Growth rates of Walleye and Northern Pike equalled or exceeded Ontario provincial averages for the first five years of growth before dropping below these averages. Smallmouth Bass grew faster than some southern Ontario lacustrine populations. Age four Walleye had the highest condition factors of all age classes examined. Age four Smallmouth Bass had one of the lowest.

Key Words: Walleye, *Stizostedion vitreum,* Smallmouth Bass, *Micropterus dolomieui,* Northern Pike, *Esox lucius*, food, growth, Ontario, Kaministiquia River.

While literature on food habits and growth of lake-dwelling Walleye (*Stizostedion vitreum*), Smallmouth Bass (*Micropterus dolomieui*) and Northern Pike (*Esox lucius*) abounds (Edwards et al. 1983; Crossman and Casselman 1987; Ebbers et al. 1988), few studies of riverine Ontario populations of these have been reported. None exist for northwestern Ontario.

In contrast to extensive commercial and sport fishermen utilization of Walleye, pike, and bass in lakes, the majority of river fishing in Ontario involves angling for Brook Trout (*Salvelinus fontinalis*) or seasonal salmonids. Most river studies have concentrated, therefore, on cold water species (e.g., Grant and Noakes 1987). If overexploited lake populations become less attractive to sportsmen, then riverine populations of coolwater species will require management which, in turn, will depend on adequate data of riverine populations. Food habit studies indicate important prey items and areas of possible prey competition. Growth rates and condition factors provide an idea of the relative "fitness" of the fish (Ricker 1975).

This study provides preliminary information on the food habits and growth rates of three popular game species in a large Ontario river. This not only provides a data base for comparison with lake populations but also with other riverine populations. The number of fish species (44) occurring in the Kaministiquia River (Cullis et al. 1990) is matched by only the largest of lakes, and provides an excellent basis for studies of preferred food.

Study Area

The Kaministiquia River (48°21'N, 89°27'W) is the largest of six major tributaries flowing into Thunder Bay, Lake Superior. The river originates approximately 64 km northwest of the City of Thunder Bay. Kakabeka Falls, with its 40.0 m drop, halts fish movement 46 km upstream from Lake Superior.

Due to degraded water quality from years of industrial use, the lower Kaministiquia River (9 km) has been designated an area of concern in the 1985 report on Great Lakes water quality by the International Joint Commission. Data on food of adult and YOY (young-of-the-year) Walleye, Smallmouth Bass, and Northern Pike were collected during a 1987 Ontario Ministry of Natural Resources (OMNR) survey of the lower 46 km of the river.

Methods

Between 9 July and 21 August of 1987, adult fish were captured along the entire length of the study area. A total of 43 Walleye, 25 Smallmouth Bass, and 27 Northern Pike adult stomachs were collected and preserved for analysis of food habits.

The entire stomach and food items found in the esophagus were removed and preserved in 10% formalin. In the laboratory, the stomach and food items were immersed in water for two minutes to remove excess formalin and subsequently placed on paper towelling for two minutes to remove excess moisture. After separation into taxonomic groups, food

items were weighed to the nearest tenth of a gram, volume determined by displacement of water, and frequency of occurrence noted. Identification of fish consumed was made using reference collections from the river and the methods outlined by Newsome (1977).

All adult fish captured during the study were weighed and their fork and total length (TL) measured. Aging tissues from Walleye and Smallmouth Bass included scales and the first three dorsal spines. The opercle was removed from those fish selected for food habit analysis. Scales were taken from Northern Pike and, in fish sacrificed for food studies, the cleithra was removed. Age analysis was performed by Jon Tost and Associates, Thunder Bay.

The 24 Walleye (55–100 mm TL), 21 Smallmouth Bass (30–61 mm TL) and 15 Northern Pike (84–196 mm TL) YOY were captured between 30 June and 29 July, from the upper river (km 23–45). They were preserved in 10% formalin on capture and their stomachs removed in the laboratory.

Adult fish were captured by angling, 1.8 m trap net, 1.4 m fyke net, 9.1 m bag seine, a Smith-Root GP 5.0 stream side shocker, a Smith-Root SR-20 electroshocking boat and index gillnets. YOY were captured with the stream side shocker or by seining.

Results

Food of Walleye

Twelve (27%) of the Walleye stomachs were empty. In the stomachs containing food, fish dominated in total volume (97%), weight (97%) and frequency of occurrence (90%). Insects, annelids and crayfish made up approximately 3% of total weight and volume and never exceeded 20% by frequency. A majority of stomachs (64.5%) contained more than one food item, although 66.7% of these contained only one species. Only one Walleye had consumed insects and no other food items were found in this stomach. There was no evidence of cannibalism. Only fish were found in the 20 YOY Walleye stomachs containing food. Four of these items were identified as catostomids.

Food of Smallmouth Bass

Seven (28%) of the Smallmouth Bass stomachs were empty. Among all items, fish occurred in the highest frequency (61%) in the 18 stomachs containing food. Crayfish (*Orconectes virilis*) dominated in total weight (88%) and volume (87%). Odonata were the most commonly observed insects in Smallmouth Bass but, the overall incidence of insects (17% frequency) was low. Smallmouth Bass had the highest number of unidentified fish remains, however; several Yellow Perch (*Perca flavescens*) were detected. More than 50% of the stomachs contained only one food item. Smallmouth Bass were cannibalistic.

Insects had a 95% frequency of occurrence in the 20 YOY Smallmouth Bass containing food. Members of Heptageniidae (mayfly) and Corixidae (water boatmen) were consumed most often. Cladocerans comprised 25%, with fish and plant materials each accounting for 15%.

Food of Northern Pike

Seven (26%) of the Northern Pike stomachs were empty. Fish dominated in terms of total weight (95%), volume (95%) and frequency (85%) in the remaining stomachs. Northern Pike ate few invertebrates (crayfish, insects). Most of the stomachs (60%) contained one food item while 30% contained two and 10% contained three. Northern Pike did not exhibit cannibalism.

In the 12 YOY Northern Pike containing food, fish constituted the highest frequency, weight and volume. Invertebrates made up a small proportion of the food. Only small fish (<100 mm TL) had eaten insects while intermediate length pike (100–140 mm TL) had eaten crayfish and leeches.

Growth and Condition

Because of high variability in growth due to the time frame involved, age 0 fish were not included in growth or condition indices. Fulton's condition factor was calculated using a modified Ricker (1975) formula ($K = \text{weight} \times 100\,000/TL^3$).

Age four Walleye had the highest condition factors. In contrast, age four Smallmouth Bass had one of the lowest condition factors but comprised the largest age class of the three species examined.

The geometric mean regression (Ricker 1975) was used to determine the log weight-length relationship of adult fish. Some adult fish, not aged due to loss or inadequate collection of aging tissues, were included in this calculation. Weight in g and TL in cm was used. The log weight-length relationship of 68 Walleye was:

$$\log W = -2.408 + 3.23(\log L).$$

For 93 Smallmouth Bass the equation was:

$$\log W = -1.944 + 3.09(\log L)$$

and for 58 Northern Pike the equation was:

$$\log W = -2.417 + 3.095(\log L).$$

Discussion

Food of Walleye

Johnny Darters (*Etheostoma nigrum*), White Suckers (*Catostomus commersoni*) and Trout-perch (*Percopsis omiscomaycus*) occurred with high frequency in Walleye collected in the upper river. Although Johnny Darters were consumed in highest frequency, other species exceeded darters in total weight and volume. In the lower 9 km of the river, "coarse" fish (suckers and Carp, *Cyprinus carpio*) were primarily consumed. Likely due to degraded water quality, Johnny Darters, Trout-perch, and several other species were absent from this area.

TABLE 1. Fulton's condition factor (modified from Ricker, 1975), number captured at age (in parentheses) and mean total length (in mm) of Walleye, Smallmouth Bass and Northern Pike collected in the Kaministiquia River, Thunder Bay, 1987.

Age	Walleye			Smallmouth Bass			Northern Pike		
1	0.8493	(12)	202	1.6035	(11)	140	0.6169	(20)	309
2	0.8643	(6)	256	–	–		0.5475	(9)	417
3	0.8827	(14)	325	1.7214	(10)	239	0.6264	(11)	488
4	1.0740	(20)	370	1.5839	(53)	283	0.6174	(6)	533
5	0.9672	(11)	427	1.7245	(2)	302	0.5474	(4)	755
6	1.0133	(1)	429	1.6184	(4)	367	0.5908	(2)	676
7	0.9390	(1)	607	1.6516	(10)	363	0.7863	(1)	885
8	–	–		1.5771	(2)	392	–	–	
10	–	–		–	–		0.6884	(1)	732
11	–	–		1.5807	(1)	451	–	–	
13	1.1187	(2)	531	–	–		–	–	

Contact with prey may come about randomly or by active search for conspicuous prey. Emery's (1973) study of daily habits of Ontario fishes showed that Johnny Darters, White Suckers and Trout-perch all fed near or on the bottom in shallow water areas. At dusk, an increase in apparent abundance was noted for these three species. White Suckers and Trout-perch often feed in aggregations (Emery 1973) and darters are often found in clumps (Page 1983). In these species, shallow water movement, schooling or feeding activity coincides with increased activity and inshore movement by Walleye (Ryder 1977). A combination of prevalence, frequenting of similar habitats, palatability, and attraction through increased activity is likely responsible for the high frequency of these species consumed by upper river Walleye.

Literature accounts of intensive use of Yellow Perch as prey in lakes are likely due to their predominance in these systems (e.g., Eschmeyer 1950). The high prevalence of suckers, darters, and Trout-perch (ranked first, second and seventh respectively) in the Kaministiquia River likely prompts Walleye to utilize prey which is frequently encountered during their own daily migrations. Yellow Perch rank fifth in prevalence here but total numbers are lower than the three species mainly consumed. The high frequency of "coarser" fish in the diet of Walleye collected in the lower river is indicative of the high prevalence of these species in that area.

Food of Smallmouth Bass

Only the largest Smallmouth Bass (age 6+) in the Kaministiquia River consumed crayfish. All of these were captured in one stretch of the river between 26 and 32 km from the river mouth.

Probst et al. (1984) report sympatric stream populations of Smallmouth Bass and Rock Bass (*Ambloplites rupestris*) consuming large numbers of crayfish in proportion to the abundance of the two crayfish species. Smallmouth Bass consumed larger crayfish in the summer and smaller crayfish in the autumn than did Rock Bass.

Rock Bass outnumber Smallmouth Bass in terms of actual numbers but not prevalence (fourth versus third) throughout the river. However; both Rock Bass and Smallmouth Bass had a 61% prevalence within this 6 km area. Since *Orconectes virilis* is the only crayfish present in the Kaministiquia River, interspecific competition with Rock Bass may limit the number or size of crayfish available for Smallmouth Bass. Other explanations include: a seasonal shift to fish (Fedoruk 1966), low numbers of crayfish in the river, high numbers of crayfish with low prey fish numbers in certain areas, or: optimal foraging by larger fish (Werner and Hall 1974).

Food of Northern Pike

White Suckers occurred with high frequency in Northern Pike stomachs. Most forage sized (30-50 mm) White Suckers were seined or electroshocked in water less than 1.5 m deep. All Northern Pike which had consumed White Suckers were seined in water of similar depth, were less than 270 mm long and were all age one. This feeding is likely accounted for by the close habitat association of Northern Pike and White Sucker. Northern Pike occurred in 45% of the seine hauls that captured White Suckers. Similarly, White Suckers occurred in 82% of the seine hauls capturing Northern Pike. Not surprisingly, all Northern Pike examined that had been seined with White Suckers had consumed some. A similar but more pronounced association between predator and prey was found between Grass Pickerel (*Esox americanus*) and Central Mudminnows (*Umbra limi*) (Crossman 1962).

The apparent randomness of other fish species consumed by Northern Pike probably reflects prey availability. The infrequent utilization of invertebrates is in agreement with other studies (Olson 1963; Diana 1979) and suggests that invertebrate consumption was opportunistic.

Food of YOY Walleye

Competition with other species for food or the lack of invertebrates in area of capture (unlikely due

to YOY Smallmouth Bass stomach contents) may be responsible for the 100% occurrence of fish consumption by YOY Walleye. Other possible explanations include: "preference" for highly available fish, a "normal" switch to fish as the main prey at this size or age; or a chance finding due to small sample sizes involved.

Food of YOY Smallmouth Bass

Tester (1932) reported that the size of the prey item consumed by Lake Nipissing YOY Smallmouth Bass was positively correlated to the size of the fry themselves. In the Kaministiquia River, small YOY bass often consumed larger prey than those consumed by the larger YOY bass examined. While Tester found a trend towards piscivory and away from cladocerans and insects as size increased, Kaministiquia River data shows the opposite.

The low frequency of occurrence of fish consumed (15%) could be the result of low availability of fish of suitable size for consumption (although YOY Walleye stomachs examined from this same area would discount this), competition with Walleye for these fish, a general low use of fish as prey at this stage (or age), and/or a larger use of invertebrates which may have been more plentiful and easier to catch in the areas frequented by Smallmouth Bass. The high total volume, weight, and frequency of insects consumed by YOY Smallmouth Bass characterizes the "normal" feeding patterns of bass of this size and age and agrees with available literature (Scott and Crossman 1973; Carlander 1977).

Food of YOY Northern Pike

The frequency of occurrence and total weight of food consumed by YOY Northern Pike were almost identical to those calculated for adults. Even at this age, Northern Pike are mainly piscivores with opportunistic feeding on invertebrates.

The majority of fish consumed by YOY Northern Pike could not be determined although Smallmouth Bass and catostomids were present. All YOY Northern Pike were seined or electroshocked in areas that also yielded White Suckers. Hence, the close habitat association between age-one Northern Pike and White Suckers in the Kaministiquia River develops early in life.

Growth and Condition Factors

Fork lengths of Walleye and Northern Pike from the Kaministiquia River were compared to Ontario provincial averages (SPOF 1983). Walleye, during their first five years, and Northern Pike, during their first four years, equal or exceed provincial growth averages. Sample sizes were too small for meaningful comparisons after age five, although lengths appear to fall short of provincial averages.

Since neither provincial averages, nor riverine population growth data exist for Smallmouth Bass in northern Ontario, Kaministiquia River Smallmouth Bass were compared with data from Scott and Crossman (1973). Kaministiquia River Smallmouth Bass lengths and weights compare favourably with those data although Kaministiquia fish do not appears to be as long lived as lacustrine fish.

Age-four Smallmouth Bass constitute a large age class, as is also true for Walleye (Table 1). Intraspecific competition may have decreased the condition factor of age four Smallmouth Bass due to a large age class. Alternatively, the high condition of Walleye at age four suggests interspecific competition may occur with Smallmouth Bass due to some habitat overlap.

Age-two Smallmouth Bass were not represented in the sample and age two Walleye and Northern Pike displayed poor condition. This suggests the possibility of interspecific competition or interference from Walleye reducing numbers of Smallmouth Bass of a similar age. Alternatively, climatic factors may be responsible for overall poor age-two year classes. An exceptionally wet spring and summer in 1985 with accompanying fluctuating water levels may have disrupted Smallmouth Bass spawning or YOY survival.

Conclusion

Kaministiquia River Walleye, Smallmouth Bass and Northern Pike exhibit good growth and condition factors compared to populations from Ontario lacustrine waters. Competition for food, defined as a 25% overlap in diet (Johnson 1977), was not detected between these species, although it may occur between Rock Bass and Smallmouth Bass. The absence of several forage species in the lower river and in the diet of fishes collected in that area strongly suggests serious water quality degradation.

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Observations on the Subtidal Distributions of the Intertidal Rough Periwinkle, *Littorina saxatilis,* and the Common Periwinkle, *L. littorea*, in a Shallow Embayment in Eastern Newfoundland

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The subtidal distribution of the predominantly intertidal Rough Periwinkle (*Littorina saxatilis*) is documented for a semi-enclosed, shallow body of water in eastern Newfoundland. This represents the first verified record of a subtidal occurrence of *L. s.* form *saxatilis* in North America. Abundance of *L. saxatilis* decreased with depth and distance offshore and individuals were restricted primarily to rocky substrata. Abundance of the co-occurring *L. littorea* did not change with increasing depth or distance offshore although mean shell height increased. The subtidal occurrence of *L. saxatilis* appears to be a phenomenon of northern latitudes. Documented occurrences of subtidal populations of *Littorina saxatilis* are rare and these tend to be recorded from relatively sheltered, semi-enclosed marine areas on both sides of the Atlantic.

Key Words: Rough Periwinkle, *Littorina saxatilis*, Common Periwinkle, *Littorina littorea*, subtidal distribution, Newfoundland.

Littorina saxatilis (Olivi 1792) is regarded primarily as an inhabitant of the intertidal zone in the North Atlantic (Raffaelli 1982). This species has an extensive geographic distribution in eastern North America, ranging from Frobisher Bay (Macpherson 1971) south to New Jersey (Bousfield 1962). Throughout its range, *L. saxatilis* is known to display considerable shell morphological variation which has resulted in the description of numerous varieties (forms) and, possibly, false species designations. There are few published records of subtidal *L. saxatilis*. Most records are of form *tenebrosa* (Thorson 1941; Muus 1967; Robertson and Mann 1982; Janson and Ward 1985). Form *tenebrosa* is considered to be an ecotype within the *L. saxatilis* group, typically occurring at high densities in shallow water (< 2 m) in sheltered bays or lagoons with reduced salinity on eelgrass (*Zostera marina*) and marine algae, or on soft muddy bottom (Muus 1967; Janson and Ward 1985). In his annotated checklist of marine prosobranchs of Iceland and east Greenland, Thorson (1941, 1944) reported the subtidal occurrence of forms of *L. saxatilis* other than form *tenebrosa*.

The differences between form *tenebrosa* and form *saxatilis* are in terms of shell characteristics; *tenebrosa* shells are considerably smaller, thinner and darker coloured than shells of form *saxatilis* (Janson and Ward 1985). Typically, form *tenebrosa* reaches a maximum shell height of between 6-9 mm (Muus 1967) although the majority of individuals in Robertson and Mann's population were < 3 mm (maximum 4.5 mm). This compares with shell heights of over 14 mm in form *saxatilis* (KDG, personal observation).

To our knowledge, the only published North American record of subtidal *L. saxatilis* represents form *tenebrosa* from a shallow, eelgrass bed in Nova Scotia (Robertson and Mann 1982). While these authors considered their study population to be comprised of *L. neglecta*, re-examination of this material revealed these littorinids to be form *tenebrosa* (Johannesson and Johannesson 1990). Thomas and White (1968) record *L. saxatilis* from Ostrea Lake, Nova Scotia however no ecological information is provided nor is the form of *L. saxatilis* identified. The following note represents the first record of North American subtidal *L. s.* form *saxatilis*. We describe patterns of distribution and abundance of this littorinid with distance offshore at an inshore site adjacent to Bellevue, in Colliers Arm, Trinity Bay, Newfoundland. We also describe zonation patterns for the co-occurring Common Periwinkle *Littorina littorea* (L. 1758).

Study Area

Colliers Arm (47°39' N, 53°44'W) is an expansive (ca. 1 km^2) semi-enclosed, sheltered marine water body. It connects to Trinity Bay through a narrow channel about 100 m wide and about 5 m deep. At the study site, the shoreline gradient is gradual such that at a distance of 100 m offshore water depths are only 5-6 m. The subtidal substrata consists primarily of gravel with mud predominating at distances of 80-100 m offshore. Subtidal macroalgae on gravel substrata is dominated by encrusting species: *Clathromorphum circumscriptum*, *Hildenbrandia rubra*, *Lithothamnion glaciale*, *Pseudolithoderma* sp. and *Ralfsia fungiformis*. Kelp growth (*Agarum cribrosum* and *Laminaria* spp.) is common at dis-

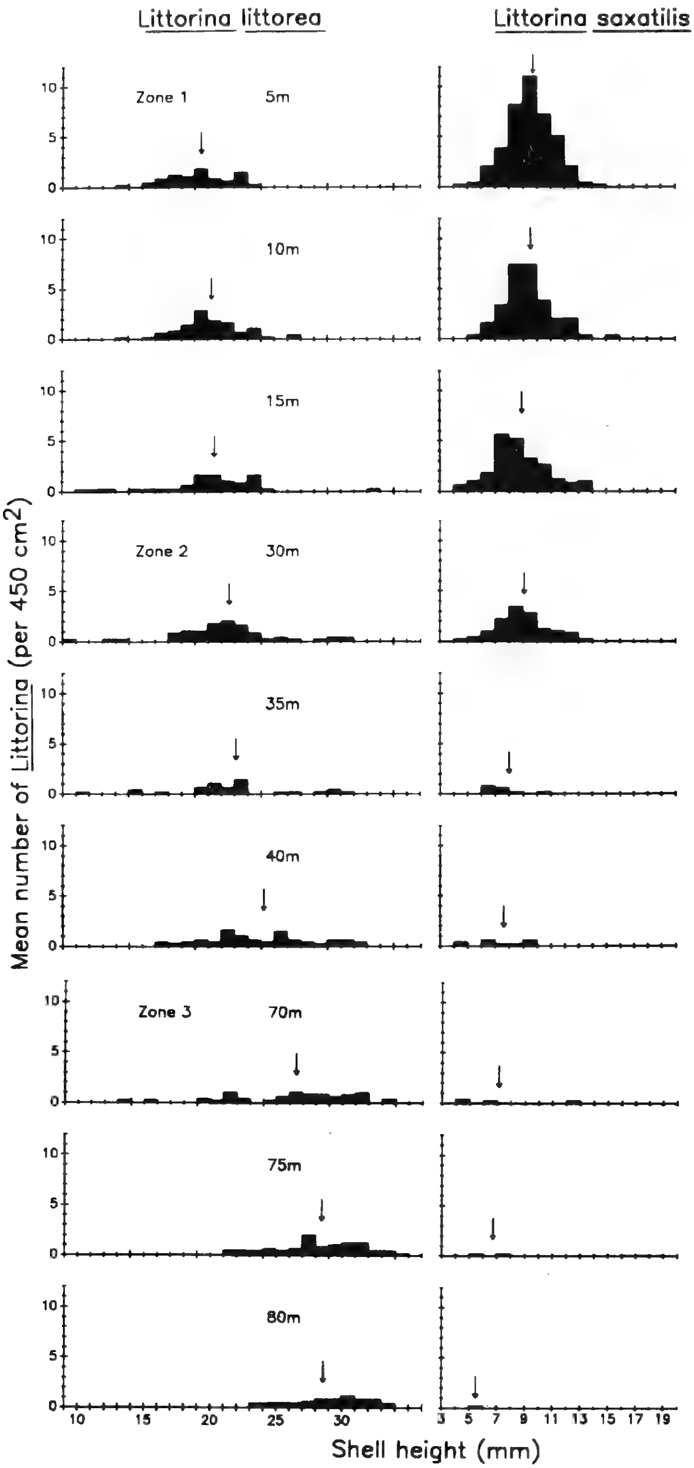

FIGURE 1. Abundance and size frequency distributions of subtidal *Littorina saxatilis* and *L. littorea* with increasing distance offshore (from ELLWS: Extreme Lower Low Water Spring). Arrows indicate mean shell height.

tances > 80 m offshore. Surface water temperatures reach 17-18°C in August and September and are less than –1.0°C in January-March when ice is present. Surface salinities range from 29-31 ppt. in July and August to 23-26 ppt. in December-March.

Methods

A subtidal transect was laid, beginning at Extreme Lower Low Water Spring (ELLWS), at right angles to the shoreline. Benthic samples were collected by SCUBA divers (Oct. 1987) on secondary transects oriented at right angles to the main transect at distances of 5, 10 and 15 m (Zone 1; depth < 1 m), 30, 35 and 40 m (Zone 2; depth ca. 2 m) and 70, 75 and 80 m (Zone 3; depth 3-4 m). Five random samples were collected from each secondary transect for a total of 15 samples per zone. All substrata and organisms within each quadrat (22.5 cm X 20 cm; 450 cm^2) were removed by a diver-operated air dredge equipped with a 3 mm mesh collection bag. Air dredge design and operation have been previously described by Martel (1982). We conducted a visual survey of Zone 4 (80-100 m offshore; depth ca. 5 m) rather than random sampling since previous dives in this area failed to reveal *L. saxatilis*.

All organisms and gravel were removed from the air dredge collection bag and transferred to plastic bags, labelled and frozen until subsequent analysis. All whole (shell with body) *Littorina* were identified, enumerated and measured (shell height) to the nearest 0.1 mm. All *Littorina* less than 4 mm shell height were excluded from analysis due to possible problems with retention in the 3 mm mesh collection bag. Representative specimens of *L. saxatilis* have been deposited in the Newfoundland and Labrador Museum (MO-1801-1830). Because of the difficulties associated with retaining the finer size fractions of sediment (particles < 3 mm) using a diver operated air dredge, our descriptions of sediments at this site are limited to qualitative observations.

Results and Discussion

Subtidal *L. saxatilis* from Colliers Arm had thick and robust shells. While most shells lacked surface sculpture, some specimens displayed concentric, raised lines which were most prominent on the lower portions of the body whorl. The columellar lip was slightly flared in most specimens. Shell colour was typically a uniform dull grey to off-white with an orange tint in certain cases. There were no instances of colour patterning (e.g., tessellation or banding). The largest specimen measured 16 mm in shell height.

The abundance of *L. saxatilis* differed significantly between transects (ANOVA, $p < 0.05$) although *Littorina saxatilis* was most abundant in the upper subtidal zone (Zone 1) ($p < 0.05$, Scheffe's Multiple Range Test) (Figure 1). Very few *L. saxatilis* were collected in Zone 3 and only one individual was observed during several visual SCUBA surveys in Zone 4. Linear regression of shell height on distance offshore (few specimens in Zone 3 excluded) showed a poor correlation ($r = -0.0932$, $n = 553$, $p < 0.05$).

Throughout Zones 1 and 2 gravel-sized rocks (≤ 20 mm) covered much of the substratum while gravel was scattered over primarily open mud bottom in Zone 3. Qualitative observations indicated that surface silt accumulation (i.e., on rocks) was largely absent from Zone 1 and increased with depth/distance offshore. Subtidal *L. saxatilis* in Colliers Arm appear to be restricted to rocky or other hard substrata. The predominance of mud and silt in Zones 3 and 4 probably limits the occurrence of *L. saxatilis*. In Britain, within the intertidal zone *L. saxatilis* generally lives where there is suitable rocky substrata (Mill and Grahame 1990).

Abundance of *Littorina littorea* was similar between transects (ANOVA, $p > 0.05$) (Figure 1). Mean shell height increased with distance offshore ($r = 0.663$, $n = 402$; $p < 0.05$). This trend may reflect a size-refugia selection pressure in response to crab predation as suggested by Ash (1989; see also Vermeij 1976). Observations made at the time of sampling indicated that Atlantic Rock Crabs (*Cancer irroratus*) were abundant subtidally in the study area.

We consider the occurrence of subtidal *L. saxatilis* to be rare in eastern Newfoundland because Colliers Arm is the only location where we have observed this species subtidally. In the United Kingdom, the occurrence of subtidal *L. saxatilis* is also considered to be rare (T. Warwick, personal communication). Locations where *L. saxatilis* are known to occur in the subtidal include Loch Bee, South Uist, Outer Hebrides, Scotland which is a large loch with a narrow entrance to the sea and Oban a'Chlachain on North Uist, Outer Hebrides, Scotland, a small body of water with a narrow connecting channel to the sea (T. Warwick, personal communication). At the latter location, *L. saxatilis* is of the form *tenebrosa* (Janson and Ward 1985).

Based on available records, the occurrence of subtidal *L. saxatilis* (all forms) is a phenomenon of northern latitudes: Nova Scotia (Thomas and White 1968, Newfoundland (this study), the United Kingdom (Janson and Ward 1985; T. Warwick, personal communication), Iceland and Greenland (Thorson 1941, 1944). However, *L. saxatilis* is not found in all subtidal habitats in northern localities. For example, subtidal *L. saxatilis* was absent along sheltered shores of western Hudson Strait, Northwest Territories, even though it was common intertidally (Gilkinson et al. 1986).

At present, we can offer no explanation for the occurrence of subtidal *L. saxatilis* in Colliers Arm. Four localities where subtidal *L. saxatilis* have been

documented (Ostrea Lake, Nova Scotia, Colliers Arm and at two sites in the United Kingdom, above) are semi-enclosed bodies of water with narrow entrances to the sea. These coastal geomorphological features may create conditions suitable for the establishment of subtidal *L. saxatilis*. Based on our field work in the study area since 1983, which has included SCUBA diving and beach seining of small fish, we feel that the occurrence of subtidal *L. saxatilis* in Colliers Arm cannot be explained by an absence of predators.

Acknowledgments

We thank D. Reid (British Museum of Natural History) for confirming our identifications of subtidal *Littorina saxatilis* from Colliers Arm and R. Hooper (Memorial University of Newfoundland) for algal identifications. We also thank D. Genge and R. Ficken of Memorial University of Newfoundland for computer graphic and photographic services, respectively. We are grateful to D. Raffaelli for reviewing an earlier version of the manuscript and to T. Warwick for providing information on habitats of the United Kingdom subtidal populations of *L. saxatilis*. This is Ocean Sciences Centre Contribution 157.

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Distribution and Habitat of the Tetraploid Gray Treefrog, *Hyla versicolor*, in New Brunswick and Eastern Maine

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*deceased 23 March 1984. See Tribute pages 592–596.

McAlpine, Donald F., Timothy J. Fletcher, Stanley W. Gorham, and Irenie T. Gorham. 1991. Distribution and habitat of the Tetraploid Gray Treefrog, *Hyla versicolor*, in New Brunswick and eastern Maine. Canadian Field Naturalist 105 (4):526–529.

Thirteen new localities for *Hyla versicolor* in New Brunswick and 15 new localities in eastern Maine are reported. These records are the first documentation that in New Brunswick the Tetraploid Gray Treefrog occurs outside the lower St. John River valley and show that this treefrog is neither rare nor endangered in the region. An examination of breeding habitat selected by the Tetraploid Gray Treefrog in Maine and New Brunswick suggests that the species range and abundance in the northeast may have been enhanced by human activities. These new records demonstrate that the species is not restricted to Herpetofaunal Section 2A in New Brunswick.

Key Words: *Hyla versicolor*, Tetraploid Gray Treefrog, distribution, habitat, Maine, New Brunswick.

The Tetraploid Gray Treefrog, *Hyla versicolor*, is the more northeasterly ranging member of a group of morphologically indistinguishable treefrogs. The two recognized species of the complex, *H. versicolor* and *H. chrysoscelis*, have a wide distribution over the eastern United States and southeastern Canada (Ralin and Rodgers 1979; Conant and Collins 1991). In Canada *H. chrysoscelis* is restricted to south-central Manitoba, while *H. versicolor* occurs through southern Manitoba, northwestern, central and southern Ontario and southern Quebec (Cook 1984). A disjunct population of this latter species has been known to occur in central New Brunswick (Barkers Point) since at least 1935 (McAlpine et al. 1980).

In 1980 (28 June, 5 July) [SWG and ITG], 1985 (22 July), 1986 (5 July) [ITG], 1988 (14 June), 1989 (19 June), and 1990 (11-15 June) [DFM and TJF] we systematically searched southwestern New Brunswick and southeastern Maine for the Tetraploid Gray Treefrog. We examined topographical maps for potential sites and usually checked the suitability of these sites in daylight and then re-visited the most likely spots between dusk and midnight. We estimated the number of frogs calling by simply listening to choruses.

Figure 1 shows the localities on both sides of the Maine-New Brunswick border where *H. versicolor* was found. Our fieldwork in eastern Maine in 1980 narrowed the gap between the Barkers Point population and Maine records to about 80 km. On 22 July 1985 we collected four Gray Treefrog tadpoles at Site 6 (Figure 1, Table 1) and on 5 July 1986 a calling male at the same site. On the latter date there was a good chorus over a radius of 2 km. In 1989 (but not in 1988) we heard many Gray Treefrogs calling along Route 6 north to Topsfield, Maine, and in 1990 located a particularly large chorus (500+) at Site 10 in New Brunswick. Numbers at other sites in 1989 varied from a single frog (Site 2) to 10-50 (Sites 1, 3, 7, 11-13, 17-27) to 50 to several hundred individuals (Sites 4-6, 8-10, 14, 15).

Activity of *H. versicolor* choruses, particularly small choruses, was sensitive to local temperature, wind, and humidity. Ritke and Semlitsch (1991) note that in the closely related *H. chrysoscelis* most individual males called for only one or two nights ($\bar{x}$ = 1.86) during a breeding season. Local climatic fluctuations and short individual periods in a chorus, combined with the small size of many choruses, may have contributed to the past difficulty in determining the true range of the Gray Treefrog in New Brunswick.

Although we have searched for the Gray Treefrog on the New Brunswick side of the border north to Centreville without success, suitable habitat is present and we believe that *H. versicolor* is distributed north of Site 1 in New Brunswick. The Maine Amphibian and Reptile Atlas project has reported a single *H. versicolor* handled, but not collected, at Houlton (John Albright, personal communication to DFM), which would support our belief.

Table 1 summarizes details of breeding habitat recorded for each of the new sites reported. Few sites were represented by undisturbed habitat and most breeding ponds had been created by road construction or the excavation of gravel. Several sites had been further modified by Beaver, *Castor canadensis*. Habitat modification may be an important factor in creating suitable breeding ponds for *H. versicolor* in this area, suggesting that the species' range and abundance at its northern distributional limits may have been enhanced by human activities.

McAlpine et al. (1980) reviewed the status of *H. versicolor* in New Brunswick and concluded that with the exception of the well documented occurrence of *H. versicolor* near the mouth of the Nashwaak River adjacent to Fredericton (Barkers Point), all remaining records known to that time

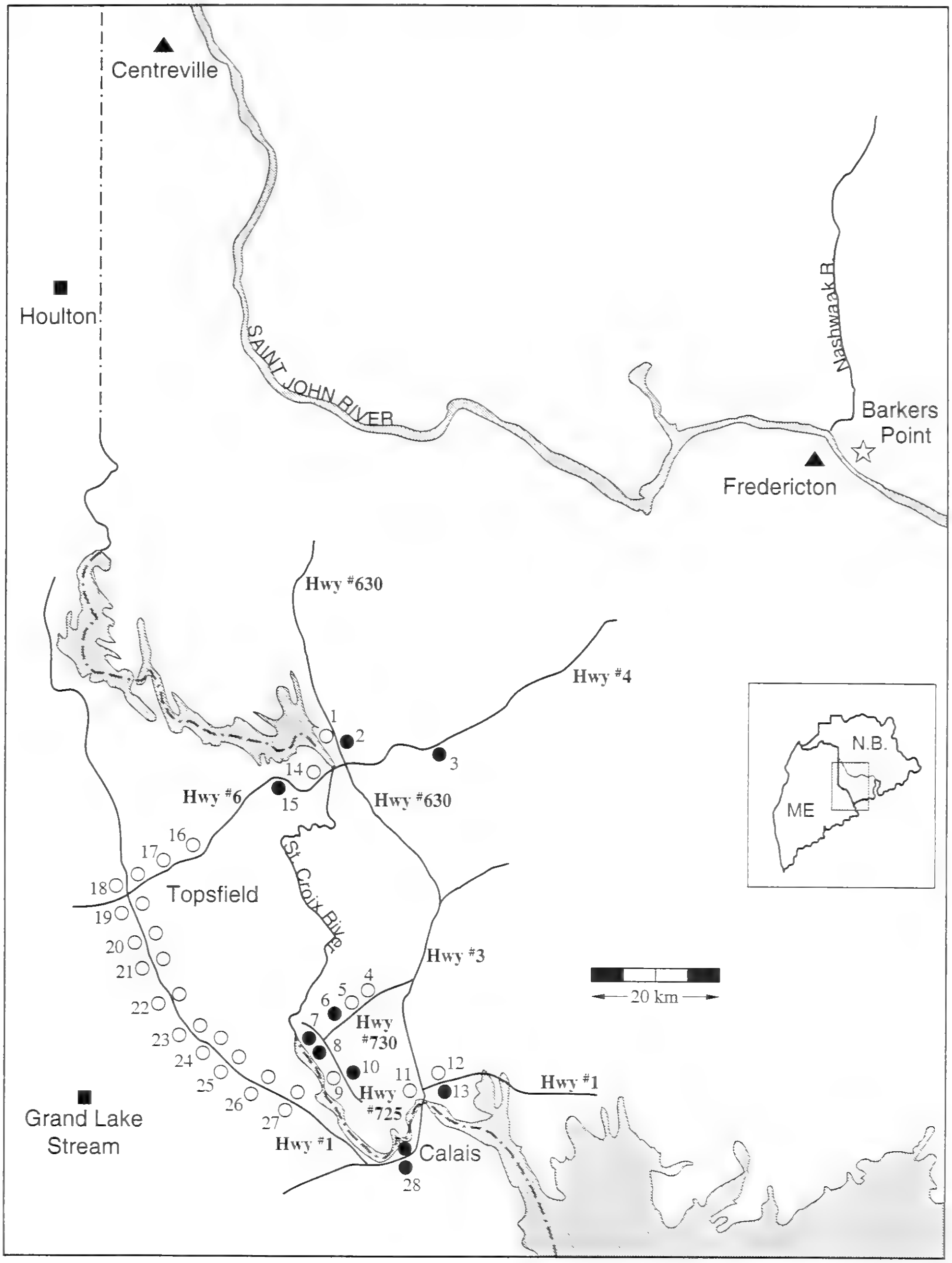

FIGURE 1. Distribution of *Hyla versicolor* in New Brunswick and eastern Maine. Closed circles show sites from which specimens were collected. Open circles show sites where calling only was recorded. Star indicates the Barkers Point site. Closed squares show the most easterly sites for Maine for *H. versicolor* as plotted by the Maine Amphibian and Reptile Atlas. Locality numbers correspond to those in Table 1.

TABLE 1. New distributional records for *Hyla versicolor* in New Brunswick and eastern Maine. Preserved museum collections are noted: NBM = New Brunswick Museum; NMC = Canadian Museum of Nature.

Site and Catalogue No.	Date	Lat/Long	Habitat
NEW BRUNSWICK			
1. Diggity Station York Co.	13 June 1990	45°37'N, 67°25'W	flooded lake perimeter
2. 2.3 km S of Diggity Station, York Co. NBM 1271	13 June 1990	45°35'N, 67°25'W	gravel pit pond
3. 3 km E of McAdam, York Co. NBM 1204	19 June 1990	45°35'N, 67°17'W	gravel pit pond
4. near Stuart Brook, Charlotte Co.	14 June 1990	45°18'N, 67 21'W	roadside pond
5. 2.5 km NE of Scotch Ridge Charlotte Co.	14 June 1990	45°17'N, 67°22'W	roadside pond
6. near Pomeroy Ridge, Charlotte Co.		45°16'N, 67°24'W	roadside marsh
NMC 27651-53 (tadpoles)	22 July 1985		
NMC 32620	5 July 1986		
NBM 1272	14 June 1990		
7. near Grand Falls Brook, Charlotte Co. NBM 1273	12 June 1990	45°16'N, 67°28'W	man-made pond
8. near Upper Little Ridge, Charlotte Co. NBM 1274	14 June 1990	45°14'N, 67°25'W	roadside pond
9. 1.5 km N of Ash Brook, Charlotte Co.	14 June 1990	45°15'N, 67°25'W	roadside marsh
10. 1 km N of Ash Brook, Charlotte Co. NBM 1268	14 June 1990	45°15'N, 67°25'W	flooded meadow
11. St. Stephen, Charlotte Co.	14 June 1990	45°12'N, 67°17'W	roadside marsh
12. 1 km E of Dennis Station, Charlotte Co.	19 June 1989 14 June 1990	45°12'N, 67°14'W	roadside marsh
13. St. Stephen Airport, Charlotte Co. NBM 1275	19 June 1989 14 June 1990	45°12'N, 67°14'W	seasonal meadow pond
MAINE			
14. Salmon Brook, Washington Co.	5 July 1985	45°34'N, 67°26'W	roadside pond
15. near Lambert Lake Washington Co. NBM 1276	19 June 1989	45°32'N, 67°29'W	roadside pond
16. near Tomah Station, Washington Co.	28 June 1980 19 June 1989	45°27'N, 67°35'W	roadside pond
17. 9 km E of Topsfield, Washington Co.	19 June 1989	45°20'N, 67°40'W	roadside pond
18-20 Topfield to near Waite, Washington Co.	19 June 1989		roadside ponds

continued on next page

TABLE 1. (Continued).

Site and catalogue. No.	Date	Lat/Long	Habitat
21. Waite, Washington Co.	19 June 1989	45°19'N, 67°40'W	bulldozed puddles
22-27. S of Waite to near Woodland, Washington Co.	19 June 1989		roadside ponds
28. 6 km S of Calais Washington Co. NBM 1155, 1209	24 June 1988 19 June 1989	45°08'N, 67°17'W	roadside pond

from the province were so poorly documented that they must be considered suspect. It appeared that the only New Brunswick population was isolated, by about 120 km, from the nearest documented records in extreme southeastern Maine (Princeton: McAlpine et al 1980; Vanceboro and near Calais: Gorham and Bleakney 1983). On the basis of this data, plus the encroaching development at the Barkers Point site, the species was considered endangered in the province and it was suggested that it was worthy of protection through legislation (Cook 1970; Stewart 1974; McAlpine et al. 1980). The new records demonstrate that *H. versicolor* is neither rare nor endangered in New Brunswick, although the Barkers Point population remains disjunct and itself remains at risk.

Bleakney (1958) demonstrated that the lower Saint John River and Grand Lake area of central New Brunswick are climatically more moderate than the rest of the province. This was based on an Environmental Temperature Index, calculated by multiplying the mean length of the growing season (number of consecutive frost free days) by the mean July temperature. Values for this index in the area matched those for his Herpetofaunal Section 2 in central Ontario and south-western Quebec. Because the Snapping Turtle, *Chelydra serpentina*, Painted Turtle, *Chrysemys picta*, Gray Treefrog, *H. versicolor,* and Dusky Salamander, *Desmognathus fuscus*, common in Section 2, also occurred in the lower St. John River and Grand Lake area he designated this region as Herpetofaunal Section 2A. Subsequently, the Dusky Salamander (Cook and Bleakney 1960) and the turtles (McAlpine and Godin 1986) have been recorded from additional localities in New Brunswick. Based on records presented here, *Hyla versicolor*, can also no longer be considered unique to Herpetofaunal Section 2A, as originally defined.

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Status of the American Coot, *Fulica americana*, in Canada*

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Lang, Anthony, L. 1991. Status of the American Coot, *Fulica americana*, in Canada. Canadian Field-Naturalist 105(4): 530–541.

I analyze American Coot (*Fulica americana*) population data for evidence of changes in population size. There is no evidence of a decline in numbers in the species' primary breeding grounds in the northern Great Plains of North America, when variations due to fluctuating precipitation levels are considered. Casual observations suggest that there are fewer coots breeding in Ontario than in the past and this is supported by weak evidence from the Breeding Bird Survey. The number of breeding coots in British Columbia appears to have increased recently. The coot's wetland habitat, however, has undergone a well documented decline across southern Canada. This has been especially dramatic in Ontario. The coot is particularly vulnerable in Ontario because of its reliance on marsh habitat, the history of wetland loss there, and the continued pressure on its habitat from the large human population. Loss of wetland habitat in British Columbia and the prairie provinces does not yet appear to have affected coot populations there. Nationally the coot should not be placed in any COSEWIC category at present.

Key Words: American Coot, *Fulica americana*, population trends, Canada, habitat loss.

The American Coot (*Fulica americana*) is a large, lobe-footed member of the family Rallidae (rails, crakes, gallinules, coots). Like most members of the family it forages and nests in marshes. It is more aquatic than most rails, anchoring its floating nests in emergent vegetation and feeding on submergent vegetation in open water. The wide breeding range of the coot covers most of North America and extends into northern South America. It is hunted over much of its range, but is popular as a game bird primarily in the southern United States. Recently there have been concerns over apparent declines in the number of breeding coots in eastern North America, particularly in Ontario. This appears to have accompanied the loss of wetlands in these areas. This paper analyzes trends in the coot's population size and examines changes in habitat quantity. Factors potentially limiting the species' population growth are also examined, based on discussions of its legal protection, habitat requirements, and general biology.

Distribution

The American Coot breeds from southern Vancouver Island, west-central British Columbia, east-central Alaska (casually), the southern Yukon, southern Mackenzie District of the Northwest Territories, northwestern and central Saskatchewan, central Manitoba, western and southern Ontario, southern Québec, southeastern New Brunswick, Prince Edward Island and western Nova Scotia locally to southern Baja California through to northwestern Costa Rica and to the coast of the Gulf of Mexico, southern Florida, the Bahamas, the Greater Antilles (Cuba, Isle of Pines, Jamaica, Hispaniola) and Grand Cayman (Figure 1) (American Ornithologists' Union 1983; Godfrey 1986). In eastern Canada it has a spotty breeding distribution confined mostly to the area south and east of the Precambrian Shield (David 1980; Peck and James 1983; Cadman et al. 1987). The lack of suitable breeding habitat seems to prevent its widespread breeding on the Shield (Cadman et al. 1987). Some of the breeding records from this area were from water bodies, such as sewage lagoons and urban lakes, that received higher than normal levels of nutrients, apparently resulting in habitat more suitable to the coot's requirements (Peck and James 1983; Cadman et al. 1987). At present, there does not seem to have been any decrease in the overall range of the species in Canada relative to that described in earlier accounts (Taverner 1940; Baillie and Harrington 1936; Godfrey 1986; Cadman et al. 1987).

The coot winters from southeastern Alaska and coastal British Columbia, south through the Pacific States and from northern Arizona, New Mexico, central Texas, the lower Mississippi and Ohio valleys and Maryland, south throughout Mexico and Central America, and southeastern United States and West Indies (south to Grenada) to eastern Panama and northern Colombia (Figure 1) (American Ornithologists' Union 1983). It winters north to southern interior British Columbia and casually to the Great Lakes in Ontario. The largest numbers of coots in the United States winter on Conchas Lake and vicinity in New Mexico and in the Imperial Valley in southeastern California. Large concentrations are also found in the San Joaquin and Sacramento Valleys, and to a lesser extent Shasta Lake, all in California.

*Report accepted by COSEWIC, April 1991. No status assigned.

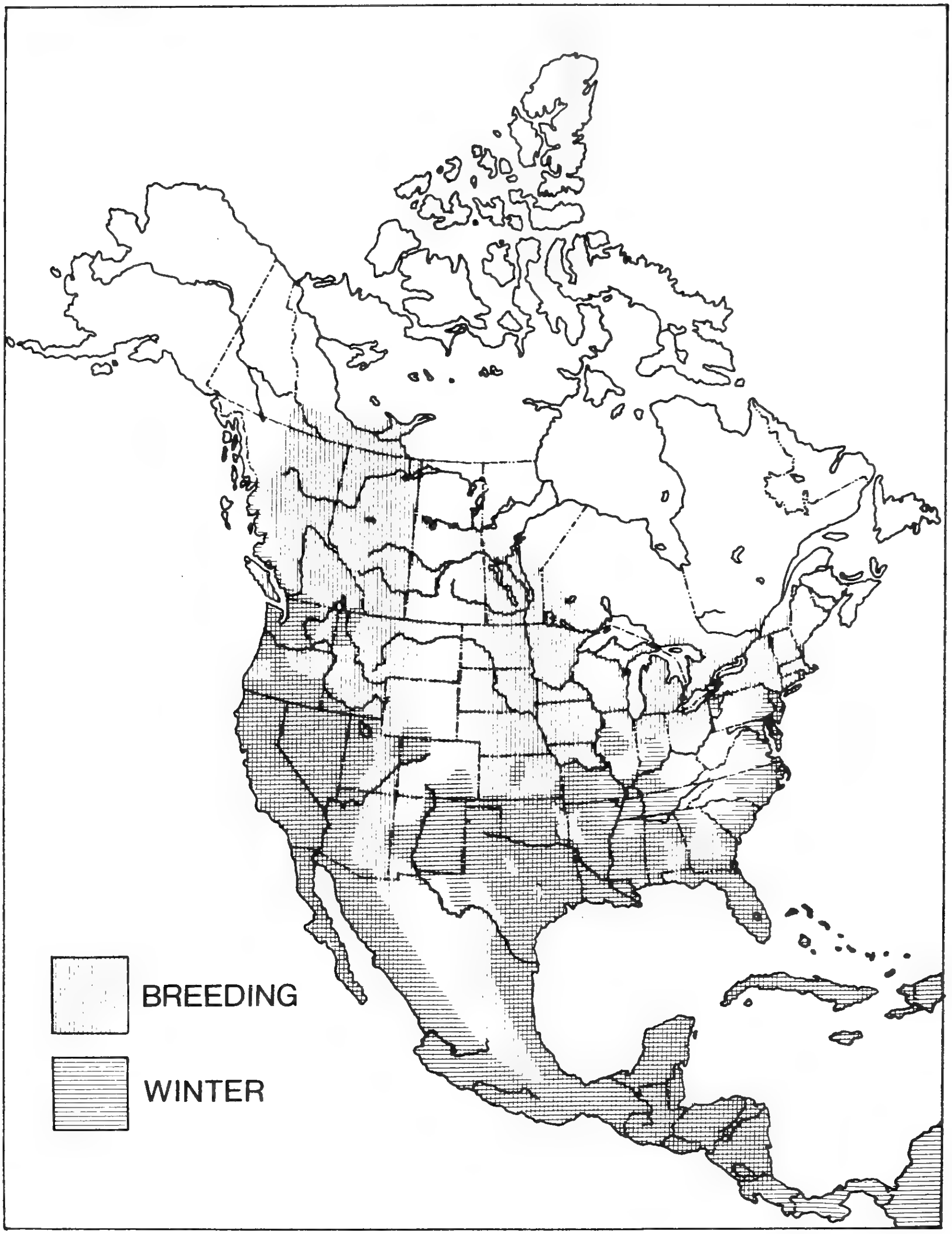

FIGURE 1. Distribution of the American Coot in North America (from American Ornithologists' Union 1983; Godfrey 1986; Root 1988).

Florida, and spots along the Gulf Coast and Mississippi valley, harbour concentrations of coots as well (Root 1988). The largest wintering coot populations in Canada are found on southeastern Vancouver Island and the Fraser Lowlands and in the Okanagan valley south of Kelowna, both in British Columbia (Campbell et al. 1990).

American Coots are resident in the Hawaiian Islands and the Andes of South America from Colombia south to western Bolivia and northern Chile and northwestern Argentina. The Andean Coot (*Fulica americana ardesiaca*) is thought to be a subspecies of the American Coot (American Ornithologists' Union 1983), although the Hawaiian

Coot (*F. a. alai*) is considered by some to be a separate species (Pratt et al. 1987).

Protection

The Migratory Birds Treaty and Act of 1917 between the United States and Canada protects the American Coot as a migratory game bird (Canadian Wildlife Service 1970). All provinces and territories except Newfoundland and Labrador, Prince Edward Island, Nova Scotia, and New Brunswick have open hunting seasons on coots in the fall (Migratory Birds Convention Act 1989). Coots are hunted in all states of the United States except Hawaii and Alaska (Elwood Martin, U.S. Fish and Wildlife Services; personal communication). The Hawaiian Coot is listed as endangered by the U.S. Fish and Wildlife Service and by the State of Hawaii (only one classification category is used in Hawaii). It is protected under the federal Endangered Species Act (Berger and Gatchell 1980). Coots are listed as "protected" in New Mexico, New York, Pennsylvania, Utah, Vermont, and Washington (Berger and Gatchell 1980).

Population Size and Trend

The American Coot is a common marsh bird in many parts of North America. Because it is hunted in most places, it is possible to obtain population estimates from various sources and regions dating to the 1950s. In Ontario, population data are uncommon and more difficult to interpret, but casual observations suggest that it is less common than in the past (Cadman et al. 1987). Coots were formerly one of the most abundant waterfowl in North America (Forbush 1912). They apparently underwent a decline in the late 1800s, likely due to the loss of wetlands in the main breeding range in the midwestern United States and Canada between 1870 and 1930 and after World War II, as well as to overhunting (Fredrickson 1977). In recent times it was still the most numerous species of bird using the glaciated prairie pothole habitat in North Dakota (Stewart and Kantrud 1972). The prairie pothole region of western North America supports an average of 63 per cent of the North American breeding duck population (Crissey 1969).

Estimates of coot populations come from Breeding Ground, Waterfowl Harvest (U.S.), and Breeding Bird surveys. Data from the first three sources are published regularly in U.S. Fish and Wildlife Waterfowl Status Reports (e.g., Novara and Voelzer 1987). Harvest data for Canada were obtained from Canadian Wildlife Service Progress Notes (e.g., Dickson 1989a). Because the number of hunters is not constant from year to year, raw harvest data cannot be used to estimate population trends. Using the ratio between the number of coots harvested and number of hunters may also be inappropriate since such a ratio will not standardize for the effect of the number of hunters unless the two variables are collinear with an intercept of zero (Jackson and Somers 1991). Instead, I regressed Canadian harvest data against the number of recreation days spent hunting migratory game birds other than waterfowl, or U.S. harvest data against the number of permits sold, to obtain a regression line. The residuals from this regression represent the number of coots harvested that were either higher or lower (or neither) than would be predicted by the number of hunters, as represented by number of recreation days spent hunting migratory game birds other than waterfowl or number of permits sold, thus removing the effect of the number of hunters. The residuals were only used when the relationship between harvest and number of hunters was linear and significantly different from zero, and when the lack of a significant relationship between those residuals and the number of hunters demonstrated that the effect of the number of hunters was removed. Linear relationships between harvest and hunter effort were found within the relatively small variation in the number of recreation days and permits (half an order of magnitude). Non-linear relationships might be expected if there were a decline in hunter success at high numbers of recreation days and/or an increase at low numbers. Where significant, linear relationships were found, the accompanying intercepts were not significantly different from zero. The residuals from coot harvest vs. number of hunters should therefore reflect real changes in the size of the population. These changes could be due to factors such as the amount of available breeding habitat or other factors. The residuals were then plotted against year to show the actual population fluctuations and trend over time. When the harvest and hunter effort data were not distributed normally, they were normalized by taking the square root of the counts.

Prairie Provinces

By far the largest coot populations in Canada are found in the Canadian prairie provinces. The best estimate of American Coot populations in this region comes from the Breeding Ground Survey. This is a cooperative effort between the U.S. Fish and Wildlife Service and Canadian Wildlife Service and consists of aerial surveys of transects, primarily in western Canada (see Dickson 1989b). Coots surveyed on transects in the prairie provinces numbered in the range of approximately 0.6 to 2.6 million birds each year, comprising about 60 per cent of the coots counted on the entire Breeding Ground Survey. Most of the rest of the coots are counted in Montana and the Dakotas. Data for the prairie provinces from 1955 to 1988 show a slight increase in coot populations which is not statistically significant (Figure 2a, $p = 0.3$). Periodic fluctuations in the population esti-

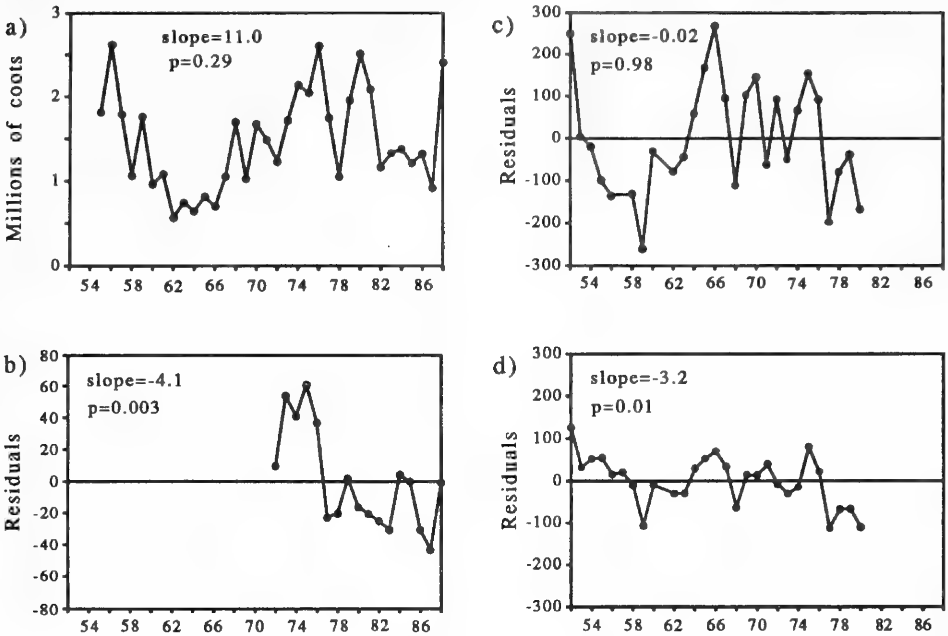

FIGURE 2. American Coot population trends calculated from various sources. Slopes and p values are from regression equations of coot numbers on time (a) or of residuals from coot harvest vs. number of hunters on time (b-c). a) Breeding Ground Survey transects in the prairie provinces; b) Canadian harvest; c) total U.S. harvest; d) Atlantic flyway harvest.

mates correspond to drought years as calculated with the Palmer Drought Index (Atmospheric Environment Service data). Coot populations decline with decreasing water levels that result from drought (Weller et al. 1958; Krapu et al. 1970; Sutherland 1991) and production of young decreases dramatically during droughts (Krapu et al. 1970; Sutherland 1991). Duck numbers on the prairies also correspond well to changing moisture levels (Boyd 1981; Jones 1984).

Breeding Bird Survey data can be used to investigate population trends since 1966, 1967, or 1968, depending on the area (Droege and Sauer 1989). Because the data recorded consist of birds seen or heard from routes along all-weather roads, marsh species tend to be undercounted. The routes do not usually traverse wetlands and marsh birds are not easily detected because of poor visibility in dense vegetation. Coots, however, feed in open water and are relatively vocal during the breeding season, so where routes do pass wetlands they may be highly detectable. In fact, significant average numbers of coots per Breeding Bird Survey route were detected in the prairie provinces. Data on population trends of species of birds along Breeding Bird Survey routes were requested from the U.S. Fish and Wildlife Service. This agency calculates trends for states, provinces, regions of North America, all of Canada, all of the U.S., and for physiographic strata (e.g., Droege and Sauer 1989). In the prairie provinces, no significant changes were detected in population sizes in Saskatchewan and Alberta from 1967 to 1988 (coots were detected on 34 and 28 routes in each of those provinces respectively). Coots were recorded on too few routes in Manitoba to draw any conclusions. No significant changes were detected in any of the physiographic strata found in these provinces.

Estimates of coot numbers during the breeding season for other regions of Canada are only available through the Breeding Bird Survey. No coots have been counted on the northwestern Ontario transect of the Breeding Ground Survey and coots rarely show up on transects in the Northwest Territories. Harvest data and hunter effort are available from 1972 to 1988 for all regions of Canada, however. The relationship between the number of coots harvested and recreation days spent hunting coots in the prairie provinces is linear and significantly different from zero (slope = 0.45, Pearson $r = 0.66$, $p < 0.01$). There is no relationship between the residuals from this regression and number of hunters (slope=3.3×10^{-2}, Pearson $r = 0$, $p = 1.0$), indicating that using the residuals removes the effect of the number of hunters. Breeding Ground Survey counts from the prairie provinces showed a poor correlation with the residuals from the regression of harvest vs. hunter effort (Pearson $r = 0.17$, $p = 0.5$). However, like waterfowl, prairie coots migrate along several fly-

ways (see discussions below), so a correlation of Breeding Ground Survey counts from all Canadian and Alaskan counts with the residuals from harvest vs. hunter effort for all of Canada from 1972 to 1988 is more appropriate. The relationship between harvest and hunter effort for all of Canada is linear and significantly different from zero (slope = 0.44, $r = 0.56$, $p < 0.05$). The relationship between the residuals and hunter effort is not significantly different from zero (slope = 8.5×10^{-15}, Pearson $r = 0$, $p = 1.0$), therefore, calculating the residuals removes the effect of the number of hunters. Comparing the relationship between the residuals and Breeding Ground Survey data produces a good correlation (Pearson $r = 0.46$, $p = 0.06$, Spearman $r = 0.46$, $p = 0.06$; had 19 years of data been available as opposed to 17 years, the same correlation coefficients would have been significant at the 0.05 level). This suggests that harvest indices may be a good estimate of population trends. The ability of these indices to provide an estimate of population trends in other parts of the country, however, may be confounded by the large numbers of coots radiating out from the prairies during migration.

British Columbia

Breeding Bird Survey data suggest that coot populations have greatly increased in British Columbia since 1968 (Table 1). A large increase was also detected in Physiographic Stratum 64 (Central Rockies: found in Idaho, and parts of Wyoming and Montana, as well as B.C.; Table 1). This stratum takes in southeastern B.C. and includes the Cariboo-Chilcotin, Okanagan, Creston Valley, Columbia River, and Kootenay River wetlands. A study in the Creston Valley showed corresponding results. There, the American Coot changed in status from being mostly transient in 1950 to being a breeding species with 478 pairs in 1983 (Butler et al. 1986).

There was no relationship between coot harvest in B.C. and hunter effort. However, banding data show that coots migrate to the Pacific states of the U.S. through B.C. from the prairies (Campbell et al. 1990), suggesting that coot harvest data may not be representative of B.C. breeding populations. Coots move through the Columbia River and Creston valleys in very large numbers on their way to wintering grounds in the U.S. Coots also move through the Okanagan valley, but many stay for the winter if the lakes do not freeze (Campbell et al. 1990). The number of coots harvested per year may also not be large enough for valid population trend estimates, since only approximately 300 to 6600 coots are harvested annually in B.C.

The apparent increase in the number of coots breeding in B.C. suggests that coots may be emigrating from the prairies because of habitat loss and recent drought there. In Canadian prairie Breeding Ground Survey data, total duck numbers decreased between 1955 and 1989, corresponding to a decrease in the number of ponds in the same area. However, total duck numbers for the same period increased in boreal regions of western Canada and in Alaska suggesting that duck breeding populations are relocating (Dickson 1989b). Continental duck populations showed no change. The drought of the 1980s, which resulted in low populations of coots in the prairie provinces during this time (Figure 2a), may have forced coots from the prairies and aspen parklands into B.C. and the boreal region of the prairie provinces. An analysis of the Breeding Ground Survey data by prairie/aspen parkland and boreal regions, however, showed no change in the number of coots in the former region but a significant increase in the latter region, mostly due to a few outlying points (not shown).

Ontario

Abundance estimates of the coot in Ontario from the Atlas of Breeding Birds of Ontario range from locally rare to locally common. It is rarest in northern Ontario and most common along the lower Great Lakes in the larger coastal marshes (Cadman et al. 1987). Coots were reported in 10 per cent of 10 km x 10 km squares (1824 in total) in southern Ontario. Breeding was confirmed in 34 per cent of these squares. In most squares where abundance estimates were available, only 10 or fewer breeding pairs were estimated to be present. Breeding was confirmed in 14 per cent of squares with coot records in northern Ontario.

Coots were recorded on too few Breeding Bird Survey routes in Ontario to draw conclusions about population trends. However, in the Great Lakes Plain (Physiographic Stratum 16, Figure 3) coots have undergone a significant decline from 1966 to 1988 (Table 1), although the small average number of birds per route suggests that little confidence should be placed in this estimate.

Coot harvest data for Ontario did not show a significant relationship to hunter effort. However, such data were not considered representative of breeding populations for that province. The total breeding population of coots in Ontario is likely small and coots harvested in Ontario would include birds migrating from the prairies to join the Atlantic and Mississippi flyways (John Harcus, Ontario Ministry Natural Resources, personal communication). From Cadman et al. (1987) ranges of abundance estimates are available for most 10 km^2 squares in which coots were detected. I used these estimates to extrapolate a range of population sizes for the area encompassed by all of the squares that had coots during the atlas survey. This resulted in an estimated population in the range of 1600 to 14 000 breeding coots in Ontario during the atlas period. Since the number of

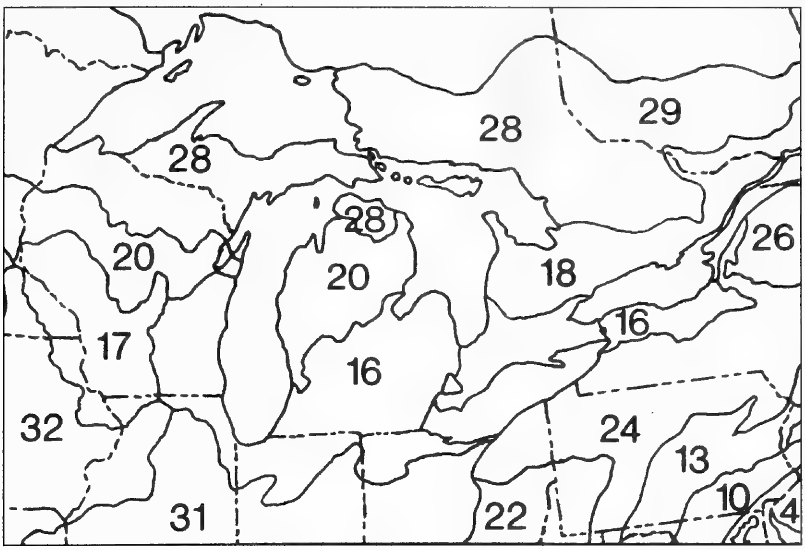

FIGURE 3. Breeding Bird Survey physiographic strata in the Great Lakes region (from Droege and Sauer 1989). A significant decline in coot numbers was detected in stratum 16 (Breeding Bird Survey data).

coots harvested annually in Ontario is very similar, this suggests that many of the birds harvested are from the prairies. Therefore, Ontario harvest data are likely not good estimates of breeding coot populations in Ontario.

Apart from quantitative data on the population status and trend of the coot in Ontario, qualitative assessments indicate that the coot population is declining locally in southern Ontario (Cadman et al. 1987). This decline has probably occurred because of the loss of habitat through draining of marshes for conversion to human land uses, but may have been slowed by the creation of sewage lagoons and impoundments that provide appropriate habitat (Cadman et al. 1987).

Quebec and the Maritime Provinces

In the provinces east of Ontario the coot is at the northeastern edge of its breeding range and is a rare breeder. The coot nests in Nova Scotia only near the New Brunswick border (Tufts 1986) and in New Brunswick itself, is a very rare breeder (Squires 1976). The coot is a rare breeder in Québec, breeding only south of the Precambrian Shield (David 1980). This seems to have been the case in the past as well (Dionne 1906). The number of coots harvested annually in Québec varies from approximately 4000 to 12 000, but given the coot's breeding status there, most of these birds are undoubtedly migrating through from the Canadian prairies.

Canada

There are no estimates for the entire Canadian breeding population of coots, however the vast majority of coots appear to be counted by the Breeding Ground Survey (see preceding discussion). Population estimates for the entire area in Canada covered by Breeding Ground Survey transects differ little from the estimates for the Canadian Prairie Provinces alone, since other transects contributed only 0 to 1.3 per cent of the coots counted. The regression line, slope, and significance level (not shown) were virtually identical to that found for the prairie provinces' populations. Total Canadian harvest, available only back to 1972, shows a slight decline (Figure 2b, slope = -4.11, p = 0.004). Much of this decline is likely due to a drought on the prairies during the 1980s (Atmospheric Environment Service data). Coot populations and reproductive output decline during time of drought (*see* Prairie Provinces section). As discussed previously, the majority of birds harvested likely come from the Canadian prairies. The Breeding Bird Survey did not detect any change in coot numbers for Canada as a whole (coots were detected on 92 routes).

United States

It is worthwhile examining populations in the U.S., especially in the northern Great Plains, since they may provide a reservoir for Canadian populations or a refuge from drought in Canada. Data from Breeding Ground Survey transects in Montana, North Dakota, South Dakota, and western Minnesota show a small increase from 1955 to 1988 (not shown). However, two outlying high counts toward the end of the period result in a large slope (slope = 22.6, p = 0.0003). These counts correspond to high counts in the same years in Canada. Numbers of coots surveyed in this area ranged from 0.2 to 2.1 million per year, but were usually well below 1 million.

No significant change was detected in Breeding Bird Survey estimates of coot populations in the United States (coots detected on 394 routes). A decrease was detected in Fish and Wildlife Region 4 (southeastern U.S.), however (Table 1).

Data on recreation days spent hunting migratory game birds other than waterfowl were not available for the U.S., but estimated total numbers of hunters were available from 1952 to 1980. The number of Canadian recreation days and the number of Canadian permits sold are significantly correlated (Pearson $r = 0.64$, $p = 0.008$; Spearman $r = 0.67$, $p = 0.005$), so the number of hunters should provide an estimate which is highly correlated with effort spent hunting coots. The number of hunters in the U.S. is significantly related to the coot harvest (slope = 1.19, Pearson $r = 0.70$, $p = 0.0001$) and this relationship is linear. The residuals from this relationship show no relationship to number of hunters (slope = 3.59×10^{-14}, Pearson $r = 0$, $p = 1.0$), indicating that using the residuals removes the effect of the number of hunters. Approximately 0.5 to 1.6 million coots are harvested each year in the United States. Data from the total U.S. harvest do not show a decline (Figure 2c, $p = 0.98$). Fluctuations in the data correspond closely with fluctuations in the Canadian Breeding Ground Survey data, which were probably due to variations in moisture levels. As mentioned previously, coots fan out from the northern Great Plains onto all of the flyways. When examined by flyway, only in the Atlantic flyway did the residuals from harvest vs. number of hunters show a decline (Figure 2d, $p = 0.01$). The relationship between coot harvest and the number of hunters in the Atlantic flyway is linear and significant (slope = 0.83, Pearson $r = 0.65$, $p = 0.0002$). The residuals showed no relationship with the number of hunters (slope = 2.94×10^{-14}, Pearson $r = 0$, $p = 1.0$). The decline in coots in the Atlantic flyway is mostly due to a high count in 1952 and low numbers from 1977 onwards, which suggests that more years of data are needed.

Synopsis

The American Coot population on its major breeding grounds, the pothole region of the northern Great Plains, appears to be stable since 1955 both in Canada and the United States as estimated by data from the Breeding Ground Survey. Approximately 60 per cent of the birds in this area are found in the Canadian prairie provinces. This population undergoes cyclic fluctuations due to moisture conditions. Breeding Bird Survey and other data suggest that there has been a large increase in the number of breeding coots in the southern interior of British Columbia. This has not been accompanied by a decline in the number of coots in the Canadian prairie pothole region, suggesting that coots have not been relocating due to habitat loss in that region. Coot numbers appear to be declining in the Great Lakes Plain, which includes much of southern Ontario, according to Breeding Bird Survey data. Casual observations by several individuals indicate that this species is declining throughout its Ontario range. The species' population size may be declining in eastern North America in general, as indicated by downward trends along Breeding Bird Survey routes in the Eastern North America Region and Fish and Wildlife Region 4 (Table 1), and to a lesser extent by declining harvests along the Atlantic flyway.

Habitat

Habitat requirements

Coots nest in marshes and feed primarily in marshes, including temporary ponds common on the prairies (Sugden 1979). They feed largely in open water (Sutherland and Maher 1987) but require emergent vegetation such as bulrush (*Scirpus* sp.), cattail (*Typha* sp.), and occasionally sedge (*Carex* sp.) or flooded willow (*Salix* sp.) in which to nest (Weller and Spatcher 1965; Sugden 1979). The nest is usually over 30 to 120 cm of water (Ehrlich et al. 1988). Coots receive most of their energy requirements for reproduction from their breeding territories (Guillion 1954; Alisauskas and Ankney 1985), so their territories must include both open water and emergent vegetation. Nests are usually placed 0.6 to 1 m from open water regardless of where the patch of emergent vegetation is in relation to the shore (Guillion 1954). Similarly, in small ponds ringed by a zone of emergent vegetation, coots placed their nests as near to open water as possible within the zone in order to minimize time and energy used to travel to open water to feed (Sutherland and Maher 1987). Open lakes support very few coots because of the lack of nesting cover (Weller and Spatcher 1965). Marshes with an equal area of open water and emergent vegetation show the highest densities of nesting coots (Weller and Spatcher 1965; Weller and Fredrickson 1973). The larger amount of cover reduces visual contact and hence intraspecific aggression, resulting in smaller inter-nest distances (Sutherland and Maher 1987). In marshes that are largely vegetated, however, access to open water for feeding is limited, so nesting density is very low (Weller and Spatcher 1965; Sutherland and Maher 1987). Fluctuating water levels are a major factor in determining the amount of vegetative cover on a marsh (Weller and Spatcher 1965). Females from lakes with higher food abundance laid heavier eggs (Hill 1988), indicating that habitat quality is also important.

Trends in habitat quantity

There has been a significant decline in the amount of area covered by wetlands throughout southern Canada since the time of settlement. In the prairie provinces, wetlands have been lost in the mixed

grass prairie region, and to an even greater extent in the aspen parkland region. In the aspen parkland of Alberta 61 per cent of wetlands had been lost by 1970. The South Saskatchewan River basin of Alberta experienced a net loss of 14 per cent of its wetlands by 1979 (Lynch-Stewart 1983) and the Battle River and its sub-basins in Alberta lost from 3 to 13 per cent of wetland area from presettlement time to 1978 (12 950 km^2 study area, National Wetlands Working Group 1988). In southern Saskatchewan 27 per cent of wetland sites had been affected by permanent impacts by 1980 (Lynch-Stewart 1983). The Minnedosa pothole region in the aspen parkland of southern Manitoba had undergone a net loss of wetland area of 40 per cent when studied in 1974 (Lynch-Stewart 1983) and a 71 per cent loss by 1982 (National Wetlands Working Group 1988) (131 km^2 study area). The Valley River watershed (Manitoba) lost 68 per cent of water and wetlands area between 1948 and 1981 (1786 km^2 study area, National Wetlands Working Group 1988). Mallard numbers on the prairies were correlated to the number of ponds from 1955 to 1970, but decreased more rapidly than predicted by the number of ponds from 1971 to 1985 (Johnson and Shaffer 1987). The number of ponds in the Canadian prairie/parkland region has undergone a significant decline since 1955 (Dickson 1989b). Duck numbers in the prairie provinces have also decreased as total cropland and wheat acreage have increased. Most of the decline in the duck population was associated with an increase in the total area of improved pasture and summerfallow (Boyd 1985). Since coot numbers do not appear to be declining on the prairies, this suggests that coots may be less dependent on small wetlands than ducks. Most of the wetland area lost on the prairies has probably been comprised of potholes. However, if larger wetlands were lost on a large scale on the prairies, coot populations there would be expected to decline.

Wetlands have also been lost in British Columbia. Twenty-seven per cent of 6571 ha of natural wetlands were converted to other uses in the southwest Fraser lowland between 1967 and 1982, but only 11 per cent were permanently lost, because some had been converted to recreational and conservation uses (Pilon and Kerr 1984). Ninety-five per cent of the wetlands in that study were freshwater, preferred by coots over salt or brackish marsh. Seasonally flooded meadows, salt and brackish marshes have undergone more severe losses (Butler and Campbell 1987). Seventy-six per cent of wetlands in Victoria have been lost (Kessel-Taylor 1984). In the Okanagan Valley, only approximately 10 to 15 per cent of the area of the formerly large marshes between Penticton and Osoyoos remain. Lake shore wetlands in the Okanagan have also been converted to other uses (Cannings et al. 1987). Of the total wetland area in the South Thompson River-Okanagan area, 22.3 per cent had been altered between settlement and 1975 (39 560 ha study area) [E. McKenzie, 1985. Preliminary assessment of wetland alienation in the South Thompson-Okanagan and Peace River-Fort St. John areas of B.C. Unpublished report, Canadian Wildlife Service, Pacific and Yukon Region, Delta, B.C.]. Most of the wetlands altered consisted of shallow open water and the disturbance in all wetland types was primarily through dams and water control. In the Peace River-Fort St. John area, 16 per cent of wetlands had been altered from settlement until 1974 (3849 ha study area) [McKenzie 1985, cited above]. Although the wetlands in this area are primarily muskeg (sedge peat fens and sphagnum bogs), 60 per cent of the wetlands altered were areas important for waterfowl migration or with high capability for waterfowl production. This area was altered due to petroleum exploration, shoreline development, cattle ranching, and to improved drainage and shrub clearing. The extensive bogs, sedge meadows and lake shoreline wetlands of the Cariboo-Chilcotin region of the Interior Plateau are also facing pressure for conversion for agricultural use (Lynch-Stewart 1983; National Wetlands Working Group 1988). From settlement until 1976, 5.75 per cent of the wetlands had been altered (14 571 ha measured to calculate alteration) [E. McKenzie, 1983. Preliminary assessment of wetland alienation in the Cariboo-Chilcotin area, B.C. Unpublished report, Canadian Wildlife Service, Habitat management and assessment, Pacific and Yukon Region, Delta, B.C.]. The majority of these wetlands were disturbed through grazing or haying (4.1 per cent) and most alienated wetlands were fens or meadows. Columbia River wetlands are now also threatened with development (Van Tighem and Baird 1991).

In southern Ontario, 2 380 000 ha of wetlands existed before settlement. Of these wetlands, 68 per cent (south of the Precambrian Shield) have been converted to other uses (Snell 1987). Extensive wetland conversions have occurred in southwestern Ontario, the Niagara Peninsula, parts of the Lake Ontario shoreline, and parts of eastern Ontario. Between 1967 and 1982, 39 290 ha were lost and 25 430 ha were gained in southern Ontario for a net loss of 1.6 per cent of the 1967 area. Some areas, however, lost much more. In Kent County a conservative estimate puts the loss at 26 per cent of the 1967 area. This figure excludes the loss of marshes within lakes, areas smaller than 10 ha, and large areas of degraded wetlands that still remain. Agriculture comprised 85 per cent of recent conversions, with cottages (draining of lake shore marshes) comprising the next largest category. Small areas were lost to urban development, idle land, recreation, extractive uses, and reforestation (Snell 1987). Lake St. Clair, part of which lies in Kent Co., lost 30 per

cent of the privately owned marsh on the east shore (1064 ha) between 1965 and 1984, mostly for agriculture (McCullough 1981). This area has experienced a 79 per cent decline in the use of this area in spring between 1968 and 1982 by true marsh dwelling species of birds, although total counts of waterfowl went up due to population increases of Canada Goose (*Branta canadensis*) and Mallard (*Anas platyrhynchos*). In the fall, there has been a 41 per cent decline in use (Dennis and North 1984). Lake Ontario has lost approximately 83 per cent of the original marshland to urban industrial development from the heavily populated western basin, leaving only 650 ha. Lake shore wetlands remaining along Lake St. Clair, Lake Erie, and Lake Ontario cover an area of 33 000 ha (McCullough 1981). Along the St. Lawrence River in Québec, 42 per cent of the original wetland area had been converted to other uses by 1975, comprising a loss of 70 km^2 (Le Groupe Dryade 1981). Given the state of the farm economy across southern Canada, tax and agriculture legislation encouraging wetland drainage, and recent droughts, wetland drainage has likely continued since these data were published. In southern Ontario, the expanding human population has put additional pressure on wetlands there. Pollution from urban and industrial sources as well as agricultural runoff is also contaminating existing wetlands. Several marshes in which coots have nested in the past in Ontario have been completely or partly drained (Ontario Nest Record Scheme data). In the absence of conclusive data that demonstrate the decline of the coot in southern Ontario, the well documented decline of its habitat can only lead to the conclusion that fewer coots are breeding in Ontario. Further loss of its habitat will only lead to an even more fragmented breeding distribution and still lower breeding populations in Ontario.

General Biology

American Coots are monogamous and usually lay 8 to 12 eggs which hatch asynchronously (Ehrlich et al. 1988) (an average of 7 to 10 in British Columbia, Campbell et al. 1990). Coots have a hatching success that varies from 48 per cent to 99 per cent (Goronzel et al. 1982; Guillion 1954; Kiel and Hawkins 1953). Guillion (1954) found that 48 per cent of hatched eggs produced fledged young. The per cent of nests fledging young ranges from 68.6 per cent to 97 per cent, and is often over 90 per cent (Goronzel et al. 1982; Hunt and Naylor 1955; Miller and Collins 1954, Wolf 1955). Younger coots nest later than older coots (Ehrlich et al. 1988). Coots will renest after successful hatching or after nest failures with slightly smaller clutch sizes (Guillion 1954).

Coots have a high reproductive potential as a result of their large clutches, their ability to breed each year, and their high nesting success. Given this, the coot is not likely limited in population growth by its nesting success and mortality, but more likely by available habitat. Restoration of formerly productive wetlands would almost certainly increase the potential for growth of coot populations.

The coot is relatively specialized in its food requirements, foraging primarily for the leaves, seeds, and roots of aquatic vegetation, e.g., pondweed (*Potamogeton* sp.), water milfoil (*Myriophyllum* sp.), the seeds of bur reed (*Sparganium* sp.) and algae (Bent 1926; Ehrlich et al. 1988; Hill 1988; Munro 1939). These are obtained primarily by diving (Bent 1926). Coots also eat wild celery (*Vallisneria* sp.), grain, and some animal food: fish, tadpoles, snails, worms, water bugs, other aquatic insects, and crustaceans (Bent 1926). Animal food, especially emerging insects, is important food for young coots. Young are fed this and vegetation by their parents for the first three weeks of life (Hill 1988). Coots occasionally feed on vegetation on land and are considered pests on southern California golf courses (Ehrlich et al. 1988).

Limiting Factors

The major factor limiting coot populations seems to be availability of habitat, as demonstrated by the dramatic decline of the coot in Hawaii (Berger 1981; Ehrlich et al. 1988) and declines in coot populations and reproductive output during droughts in North America. Although the coot is at the northern limit of its breeding range in Canada, it does not seem to be limited by latitude but by habitat, as shown by the breeding of coots in suitable habitat in northern Ontario (Peck and James 1983) and British Columbia. There has been a significant loss in the total area of wetlands across southern Canada. This has been especially severe in southern Ontario, the southwest British Columbia mainland, and the Okanagan valley. It has likely caused the coot's breeding distribution to become more fragmented in Ontario. With fewer wetlands available, fewer still are available at a desirable successional stage to provide satisfactory coot breeding habitat. Wetland loss on the prairies does not yet seem to be limiting the coot population there. The coot may be experiencing wetland loss on its wintering grounds, however. Wetland losses have occurred all across eastern North America. Wetlands in Florida, where large numbers of coots winter, have experienced especially heavy losses.

Hunting may also limit coot population growth, although many authors have presented evidence that up to a limit, hunting mortality in waterfowl replaces other forms of mortality, thus not creating a negative impact on the population (e.g., Anderson and Burnham 1978). This may also be the case for coots. The number of hunters has been decreasing in Canada and the United States since 1982, and with

this the number of ducks harvested annually. The number of geese harvested has levelled off in Canada but is declining in the U.S. (Boyd 1988).

Special Significance of the Species

The American Coot is hunted as a migratory game bird. Because it is not very palatable, it is less desirable than other species of waterfowl, but it is still an important component of the annual harvest, comprising 3-4 per cent of the total annual waterfowl kill in the United States. Fifty-eight per cent of the coot harvest in the U.S. takes place in the Mississippi flyway (Martin 1979). Louisiana accounted for more than one quarter of the U.S. harvest with California and Wisconsin together amounting to another quarter (Martin 1979). In Canada, the number of coots killed each year comprises only approximately 0.5 per cent of the roughly three million waterfowl harvested annually. Only about 0.4 per cent of the waterfowl harvested each year in Ontario and Québec are coots.

Evaluation and Proposed Status

American Coot population levels in Canada and the U.S. do not appear to have declined since 1952. The coot is still widespread in North America and numbers in the order of a few million birds. Given its high reproductive potential, it seems limited primarily by the availability of suitable wetland habitat. Its habitat has been reduced in area throughout its breeding range since settlement, however. Although quantitative evidence is scanty, long term qualitative evidence from observers in Ontario, as well as indirect evidence from the loss of wetlands, suggest that the Ontario coot populations are declining. As a result, the coot should be watched carefully in Ontario, particularly because it depends entirely on a habitat which itself is so vulnerable. However, nationally there does not seem to be evidence of a decline sufficient to suggest that it be put in any COSEWIC category at present.

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An Unusual Population of Galls of *Diplolepis polita* (Hymenoptera: Cynipidae) in the Cypress Hills of Southeastern Alberta

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Shorthouse, J. D. 1991. An unusual population of galls of *Diplolepis polita* (Hymenoptera: Cynipidae) in the Cypress Hills of southeastern Alberta. Canadian Field-Naturalist 105 (4): 542–549.

Galls of *Diplolepis polita*, typically found on partially shaded *Rosa acicularis* throughout the wasps' range east of the Rocky Mountains, were found on *Rosa arkansana* growing on a grassy plateau of the Cypress Hills in southeastern Alberta. Populations of the Cypress Hills galls widely fluctuate from year to year compared to other parts of the species' range. Composition of the associated community of parasitoids and inquilines in Cypress Hills galls differs from that in galls found in other areas. It is postulated that cooler temperatures of the Cypress Hills affect gall growth and the success of parasitoids and inquilines in locating galls.

Key Words: *Diplolepis polita*, Hymenoptera, Cynipidae, *Rosa acicularis*, *Rosa arkansana*, galls, Cypress Hills, Alberta.

Cynipid wasps of the genus *Diplolepis* induce galls on either the leaves, stems or roots of wild or domestic roses (Shorthouse 1988). There are about 30 species of *Diplolepis* in North America (Burks 1979) and half are found in Canada. As with the galls of all cynipids, the larvae of *Diplolepis* are attacked by numerous species of parasitoids and the tissues of their galls fed upon by the larvae of inquilines (inquilines are insects that feed on gall tissues without directly damaging larvae of the gall-inducer). The assemblage of gall inducers, parasitoids and inquilines found in a large population of galls induced by the same species forms a miniature community with a definite functional unity, characteristic trophic structure and compositional unity that persists from one year to the next. Assemblages of this type are referred to as closed (Askew 1975) or component communities (Root 1973) and the processes that determine their nature and structure is an area of current interest in ecology (for reviews *see* Askew 1975; Askew and Shaw 1986; Claridge 1987; Lawton and MacGarvin 1986). It also is assumed that the composition of these communities is similar throughout the range of the gall inducer. Schroder (1967), for example, found that galls of *Diplolepis rosae* contained the same species of inhabitants across Europe.

Little information has been published on the distribution of *Diplolepis* in Canada; however, data collected by the author indicate that most species are host specific, their galls are found in a particular habitat and the composition of their component communities are similar throughout the range of the gall inducer. Therefore, it is of interest when unusual records of host, habitat, abundance or associated component communities are obtained. Here I report on one such occurrence, an unusually large population of galls of *Diplolepis polita* found on an atypical host in the Cypress Hills of southeastern Alberta.

Biology of *Diplolepis polita* and its gall

Diplolepis polita induces one of the most widely distributed leaf galls in Canada and its life cycle, host and organ specificity, gall development and associated component community of inhabitants have been reported elsewhere (Shorthouse 1973, 1975, 1980). Like all species of *Diplolepis*, it is univoltine, overwinters as a prepupa within its gall and adult emergence in the spring is synchronized with the appearance of tissues susceptible to galling. The weakly spined, spherical, single-chambered galls occur sporadically on the adaxial surface of the leaflets (Figure 1). Most populations of galls are attacked by six species of parasitoids [*Eurytoma longavena* (Family Eurytomidae), *Glyphomerus stigma* (Family Torymidae), *Torymus bedeguaris* (Family Torymidae), *Habrocytus* sp. (Family Pteromalidae), *Tetrastichus* sp. (Family Eulophidae), and *Ormyrus* sp. (Family Ormyridae)] and an inquiline of the genus *Periclistus* (Family Cynipidae). This as yet unidentified species of *Periclistus* is found throughout the range of *D. polita*. The female kills the immature larva of *D. polita* at oviposition and then her phytophagous larvae not only displace the larva of *D. polita* and enlarge and structurally modify the inhabited gall (Shorthouse 1980), they also serve as food for the parasitoids (Shorthouse 1973, 1975). *Periclistus* sp. are usually found in about 70% of the galls by early June, with a corresponding decrease in the percentage of galls containing an inducer (Shorthouse 1973). The combined attacks of both inquilines and parasitoids commonly reduce the population of *D. polita* in mature galls, prior to overwintering, by 90% (Shorthouse 1973). Results of all interactions between parasitoids, inquilines and the inducers throughout the season influence gall abundance and the composition of the component community the following spring. Interrupted ovipositions by parasitoids and food shortages due to superparasitism and multiparasitism commonly result in the death of all inhabitants resulting in about 25% of all galls being empty by maturity (Shorthouse 1973). Also, some *Eurytoma* and *Torymus* emerge in

August of the season the galls are initiated. These adults are thought to oviposit into late maturing galls or galls of other species (Shorthouse 1973).

Galls of *D. polita* are found in a broad arch across central Canada from Vancouver Island, British Columbia to central Ontario (unpublished data). They also occur in central Alaska, U.S.A., and the Yukon (Shorthouse 1975), but not in Quebec or the Maritimes. *D. polita* galls only *Rosa acicularis* east of the Rockies and *R. nutkana* west of the Rockies. Ideal hosts for galling are those averaging about 0.75 m in height growing at the edge of clearings (Figure 2) or on disturbed lands where the host receives some shade. *R. acicularis* is the most widely distributed rose across central Canada south of the treeline (Lewis 1959). It is especially abundant in central Alaska and the Yukon (Viereck and Little 1972), in northern Alberta, Saskatchewan, and Manitoba (Moss 1953) and across central and northern Ontario (Soper and Heimburger 1982). It is less common south of the aspen parkland in western Canada and becomes restricted to wooded areas along river banks and elevated lands such as the Cypress Hills (Breitung 1954).

The Cypress Hills

The Cypress Hills (49°40'N, 110°15'W) are a flat-topped plateau of about 2500 square kilometres that straddle the southern Alberta-Saskatchewan border, about 60 km south and east from Medicine Hat, Alberta. The area is a humid island in the semiarid prairies with many species of plants and animals representative of the Rocky Mountains over 240 km to the west (Russell 1951; Bird 1962; Bird and Halladay 1967; Newsome and Dix 1968). It has been suggested that the biota of the Cypress Hills was once connected to the Rockies to the west in early postglacial times. Capped by a layer of stream-laid gravels and boulders up to 100 m thick derived from the Rockies, the Cypress Hills are an erosional remnant of once-extensive higher level plains. The hills were high enough to have been one of the few areas in Canada not completely ice-covered during the Wisconsin glaciation. The hills form a rolling plateau-like upland with Lodgepole Pine, White Spruce, Balsam Poplar and aspen forests. Those on the Alberta side rise about 600 m above the surrounding dry, short-grass prairie and this elevation results in higher precipitation and lower temperatures than the surrounding plains (Holmes 1969). The daily mean temperature for July in the Cypress Hills is 15.0°C and the annual precipitation is 50 cm, whereas the daily mean temperature for July at Medicine Hat is 21.0°C and the annual precipitation is 33 cm (Holmes 1969).

Materials and Methods

An extremely dense population of maturing galls of *D. polita* was observed in the Cypress Hills on 8 August 1986 on a tree-less plain about 5 km south of the Elkwater townsite. The galls were too immature to rear the inhabitants, but a large collection was returned to the laboratory in Sudbury for dissection. The collection site was shown to a colleague living nearby and arrangements made for a collection of mature galls on 20 September 1986. These galls were sent to me for dissection and rearing of inhabitants. The site was again examined in August 1987 by the colleague and by me in July of 1988. I made another examination of the site and gall collection in August of 1990.

The Cypress Hills galls are compared to those from other regions of western Canada: George Lake (53°57'N, 114°06'W) about 75 km north of Edmonton, Alberta; about 45 km north of Prince Albert, Saskatchewan (54°0'N, 106°50'W); near Dawson City, Yukon (64°04'N, 139°24'W); and in Ontario in the eastern part of Manitoulin Island (45°44'N, 82°10'W). In all cases, collections were made by harvesting all observed galled leaves as the collector walked haphazardly through patches of rose. Unfortunately, data on the number of galls inhabited by each species in the community and data on the total number of inhabitants found in each community were not obtained for all sites; however, there are sufficient data from each site to illustrate the uniqueness of the Cypress Hills population. In the case of the Manitoulin Island collection, only data on the number of *Periclistus* per gall were obtained. Voucher specimens from the Cypress Hills galls have been deposited in the Canadian National Collection of Insects, Agriculture Canada, in Ottawa, Ontario.

Results and Discussion

The population of *D. polita* galls found in the Cypress Hills on 8 August 1986 was the largest and most dense observed by the author throughout the range of this species. Almost every plant on the plateau (an area of about three square kilometers) had several dense clusters of galls and some plants had so many galls (Figure 3) that the branches were bent with their weight. Most galls were light green and in such thick clusters that they curled the leaf into a ball. Galls normally are found distributed over the surface of the leaflets (Shorthouse 1973) and rarely cause the leaves to curl (Figure 1). Galls at the Cypress Hills site were so abundant that a sample of 997 maturing galls was collected in about 20 minutes.

Of interest, all galls were found on *Rosa arkansana*, the first time *D. polita* has been recorded on this host. *R. arkansana* is a short rose (averaging 20 cm in height) that grows in the open on dry soil. It is restricted to Nearctic prairie regions and is found from Alberta and Saskatchewan to Texas, U.S.A. (Little 1942). It is common on the mixed, fescue and transitional fescue-mixed prairie of southern

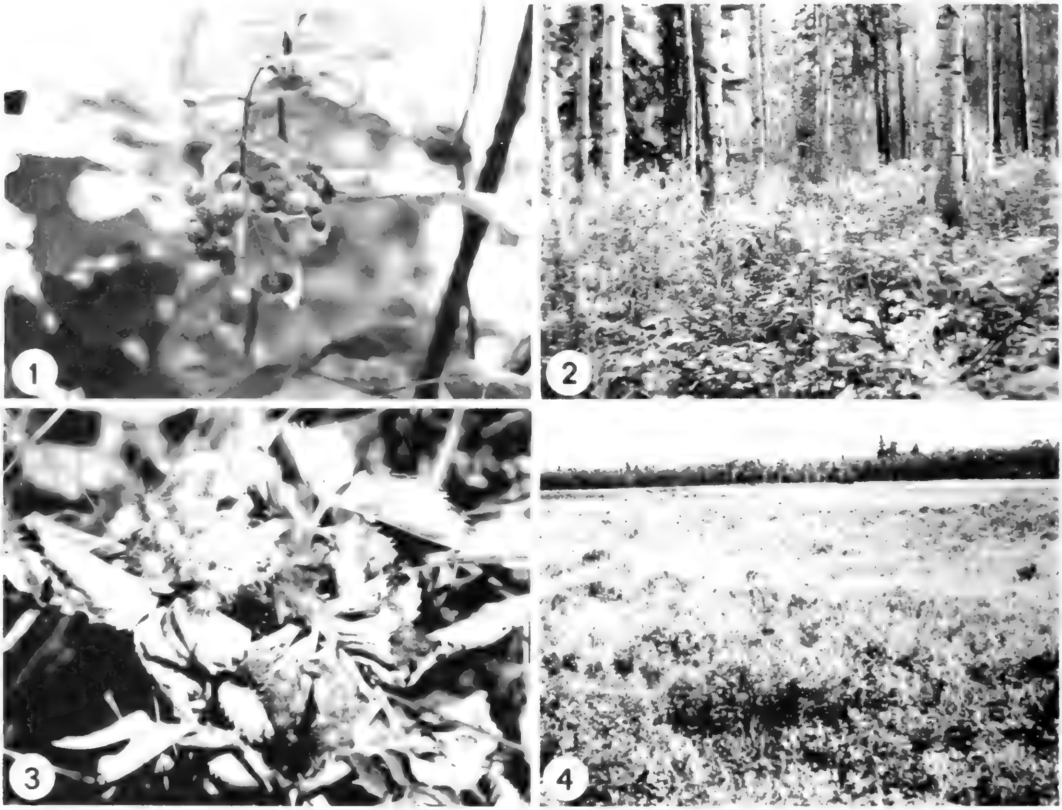

FIGURE 1. Galls of *Diplolepis polita* on the leaves of *Rosa acicularis* in central Alberta.
FIGURE 2. Typical habitat of *Rosa acicularis* and *Diplolepis polita* in central Alberta.
FIGURE 3. Galls of *Diplolepis polita* on the leaves of *Rosa arkansana* in the Cypress Hills.
FIGURE 4. Habitat of *Rosa arkansana* and *Diplolepis polita* in the Cypress Hills.

Alberta and Saskatchewan (outlined by Coupland 1961), as well as on northern prairies near Peace River, Alberta (Moss 1952) and on plateaux of the Cypress Hills (Breitung 1954). In contrast to *R. acicularis*, the normal host of *D. polita* which normally grows in association with boreal or mixed wood forests, aspen parkland or wooded river valleys of the southern prairie, *R. arkansana* grows in drier, open and tree-less habitats. The habitat of *R. arkansana*, in which the 1986 collection was made (Figure 4), is typical for this species.

The inhabitants of all 8 August galls were too immature at the time of collection to obtain adults; however, the collection was made in order to study composition of the inhabitant community. Typically, most galls of *D. polita* contain mature larvae of either the inducer, inquiline or parasitoids by early-August and begin falling to the ground (Shorthouse 1973). In contrast, it appears that development of inhabitants in the August 1986 Cypress Hills galls was substantially delayed and gall maturation would not occur until early September. It is also possible that the delay in maturity of 1986 galls was caused by the high density of galls; that is, the host organs simply did not have adequate resources for such dense clusters of galls.

Parasitoids can oviposit in galls of *D. polita* until the galls start to mature and harden. In typical habitats, parasitoids do not oviposit beyond early August. Furthermore, the combined effects of *Periclistus* inquilines and parasitoids result in less than 10% of the galls containing a viable larva of *D. polita* by early August (Shorthouse 1973). In contrast, 70.5% of the galls collected on 8 August in the Cypress Hills had a viable *D. polita*, 23.3% had an inquiline and less than 5% of the galls had a live parasitoid (Table 1). In typical habitats by this date, parasitoids would have reduced the percentage of galls containing both inquilines and the gall inducer to less than 15% indicating that in the Cypress Hills, adult parasitoids are active and continue ovipositing until late summer. By September of 1986, the actions of parasitoids reduced the Cypress Hills galls containing a *D. polita* larva to 24.6% and those with parasitoids

TABLE 1. Percentage of galls inhabited by various members of the *Diplolepis polita* community. Numbers in parentheses are the total galls containing the particular inhabitant.

Galls inhabited by community members	Collection sites: George Lake Alberta 22-VIII-69	Cypress Hills Alberta 8-VIII-86	Cypress Hills Alberta 20-IX-86	Cypress Hills Alberta 21-VIII-90
Diplolepis polita	3.0% (8)	70.5% (703)	24.6% (61)	7.1 (13)
Periclistus sp.	8.5% (23)	23.3% (233)	31.0% (77)	31.1 (57)
Eurytoma longavena	32.1% (87)	0.3% (3)	9.7% (24)	17.4 (32)
Glyphomerus stigma	12.5% (34)	2.9% (29)	11.9% (29)	22.9 (42)
Torymus bedeguaris	4.0% (11)	1.5% (15)	-	2.1 (4)
Habrocystus sp.	8.1% (22)	-	0.4% (1)	-
Tetrastichus sp.	-	1.0% (10)	1.6% (4)	-
Empty	27.7% (75)	0.4% (4)	21.0% (52)	19.1 (35)
Emergence holes	4.0% (11)	-	-	-
Total galls	271	997	248	183

increased to about 24% (Table 1). Twenty-one percent of the galls were empty (Table 1) which I suspect was due to the immaturity of *Periclistus* larvae prior to gall maturation. None of the parasitoids emerged in the fall.

The distinctiveness of the Cypress Hills galls is also evident when the total assemblage of inhabitants in mature galls is compared with that found in mature galls from central Alberta and Saskatchewan (Table 2). In September, 1986, the Cypress Hills community was composed of more gall inducers and inquilines and fewer parasitoids than the more northern communities. The low numbers of parasitoids likely allow the inquiline population to remain high throughout the season. In other areas, parasitoids such as *Eurytoma longavena* are major consumers of *Periclistus* inquilines, commonly reducing their population by about 50% by end of the season (Shorthouse 1973). The main food of *Glyphomerus stigma* is the larva of *D. polita* and the relatively high population of this species in the 1986 Cypress Hills community indicates that a lower percentage of the galls were inhabited by inquilines. *Habrocytus* sp. mainly feed on the larvae of *Periclistus* and are important community members in typical habitats (Table 2). Their absence in the Cypress Hills further reflects the reduced role of inquilines in this community.

Although the August 1990 collection was made before all inhabitants had matured, and population changes due to the parasitoids would continue, it appears that the *Periclistus* inquilines would still be a dominant community member by fall and that *G. stigma* would remain an important factor decreasing the population of *D. polita*. Of interest, *Torymus bedeguaris* entered the Cypress Hills community in 1990. It may have been an incidental species in the persisting community or it may have come from galls of other nearby species of *Diplolepis* (e.g. *D. bicolor* and *D. lens*), small numbers of which are also found on the Cypress Hills *R. arkansana*.

A further indication of the reduced role of *Periclistus* in the Cypress Hills is seen in the size of inquiline-modified galls. Whereas the size of mature galls inhabited only by *D. polita* was similar from

TABLE 2. Inhabitants found in mature galls expressed as percent of total number of larvae in entire gall collection. Numbers in parentheses are the total larvae of the particular inhabitant.

Species of inhabitants	Collection sites: Prince Albert Saskatchewan 10-VIII-72	George Lake Alberta 22-VIII-69	Cypress Hills Alberta 20-IX-86	Cypress Hills Alberta 21-VIII-90
Diplolepis polita	4.6% (10)	2.7% (8)	18.5% (61)	5.9% (13)
Periclistus sp.	23.7% (52)	27.2% (80)	64.1% (211)	58.8% (130)
Eurytoma longavena	20.0% (44)	29.6% (87)	7.3% (24)	14.4% (32)
Glyphomerus stigma	4.1% (9)	11.6% (34)	8.8% (29)	19.0% (42)
Torymus bedeguaris	4.6% (10)	3.7% (11)	-	1.8% (4)
Habrocystus sp.	39.7% (87)	25.1% (74)	-	-
Ormyrus sp.	3.2% (7)	-	-	-
Tetrastichus sp.	-	-	1.2% (4)	-
Total larvae	219	294	329	221

TABLE 3. Mean diameters (in mm) of mature galls inhabited by either *Diplolepis polita* or *Periclistus* sp.

Gall Inhabitants	Collection Site	Number of Galls	Gall Diameters
D. polita	Dawson City, Yukon	38	3.6 ± 0.11*
D. polita	George Lake, Alberta	14	3.9 ± 0.11
D. polita	Cypress Hills, Alberta (1986)	60	4.0 ± 0.08
D. polita	Cypress Hills, Alberta (1990)	13	3.1 ± 0.14
Periclistus sp.	Dawson City, Yukon	70	5.6 ± 0.19
Periclistus sp.	George Lake, Alberta	63	6.8 ± 0.16
Periclistus sp.	Cypress Hills, Alberta (1986)	77	4.2 ± 0.13
Periclistus sp.	Cypress Hills, Alberta (1990)	57	3.3 ± 0.17

*standard error of the mean

the Cypress Hills to the Yukon (Table 3), Cypress Hills galls inhabited by *Periclistus* were smaller than those at other sites (Table 3). Since size of inquiline-modified galls depends on the number of larvae present (Shorthouse 1973), the smaller Cypress Hills galls reflect a smaller population of *Periclistus* adults in late spring which would result in fewer eggs being laid per gall. Indeed, the Cypress Hills galls both in 1986 and 1990 had fewer *Periclistus* larvae per gall than did galls from other regions (Table 4). Furthermore, frequency distribution graphs of the Cypress Hills data for the number of *Periclistus* per gall show larval numbers strongly skewed to the left with a mode of 2-3, whereas galls from Manitoulin Island in Ontario and Dawson City, Yukon had a mode of 2-4 (Figure 5).

The presence of *D. polita* in about one-quarter of the galls in the fall of 1986 should have been an indication that galls were to be abundant again the following season. However, the collector who made the 20 October 1986 collection returned to the same site the following August and could not find a single gall. I returned to the site in early July of 1988 and also found no galls indicating that the population of *D. polita* crashed at this site after 1986. However, a small population was present in August of 1990 and I was able to collect 183 in about one hour of intensive searching. Most galls were evenly distributed over the leaf surface rather than in clusters as in Figure 2. Of these galls, 7.1% contained a *D. polita*, 31.1% had inquilines and 42.4% contained parasitoids. All but one of the *D. polita* larvae were sufficiently mature to survive; however, many galls with other inhabitants were small and likely would not mature by fall. Of the 57 *Periclistus* -inhabited galls, 9 had immature, first- or second-instar larvae that likely would not survive. All *G. stigma* were sufficiently mature to survive. In typical habitats by this date, 90% of all galls would be mature by mid-August and 75% would have fallen by the first week of September (Shorthouse 1973). The presence of *D. polita* in 7.1% of the galls and the apparent failure of some *Periclistus* to mature likely insured that galls would have been reestablished in 1991. Decreases in populations of *Periclistus* likely lead to a decrease in *Eurytoma longavena*, a species that mainly feeds on inquiline larvae, whereas the numbers of *G. stigma* will likely increase since this species mainly feeds on the larvae of *D. polita* (Table 1).

The population of *D. polita* galls in the Cypress Hills provides insight into aspects of cynipid biology on which we have much to learn. Firstly, it is further evidence that *Diplolepis* are not strictly host specific. However, it is interesting that *D. polita* would attack *R. arkansana* on the plateau of the Cypress Hills, but not on the surrounding drier plains. Perhaps the moist conditions of the Cypress Hills or the phenological differences in plants makes *R. arkansana* susceptible when adults of *D. polita* are active. The cooler conditions of the plateau undoubtedly delay and prolong leaf development in the spring and thus may synchronize adult wasps and suitable oviposition sites.

Whereas the composition of cynipid gall communities is usually influenced by the interactions among the inhabitants (Askew 1984; Shorthouse 1973;

TABLE 4. Mean number of larvae of *Periclistus* sp. per gall.

Collection Site	Number of Galls	Mean number of larvae
Dawson City, Yukon	67	4.6 ± 0.37*
George Lake, Alberta	21	3.2 ± 0.70
Prince Albert, Saskatchewan	350	5.4 ± 0.24
Manitoulin Island, Ontario	116	3.8 ± 0.22
Cypress Hills, Alberta (1986)	77	2.9 ± 0.24
Cypress Hills, Alberta (1990)	57	2.3 ± 0.24

*standard error of the mean

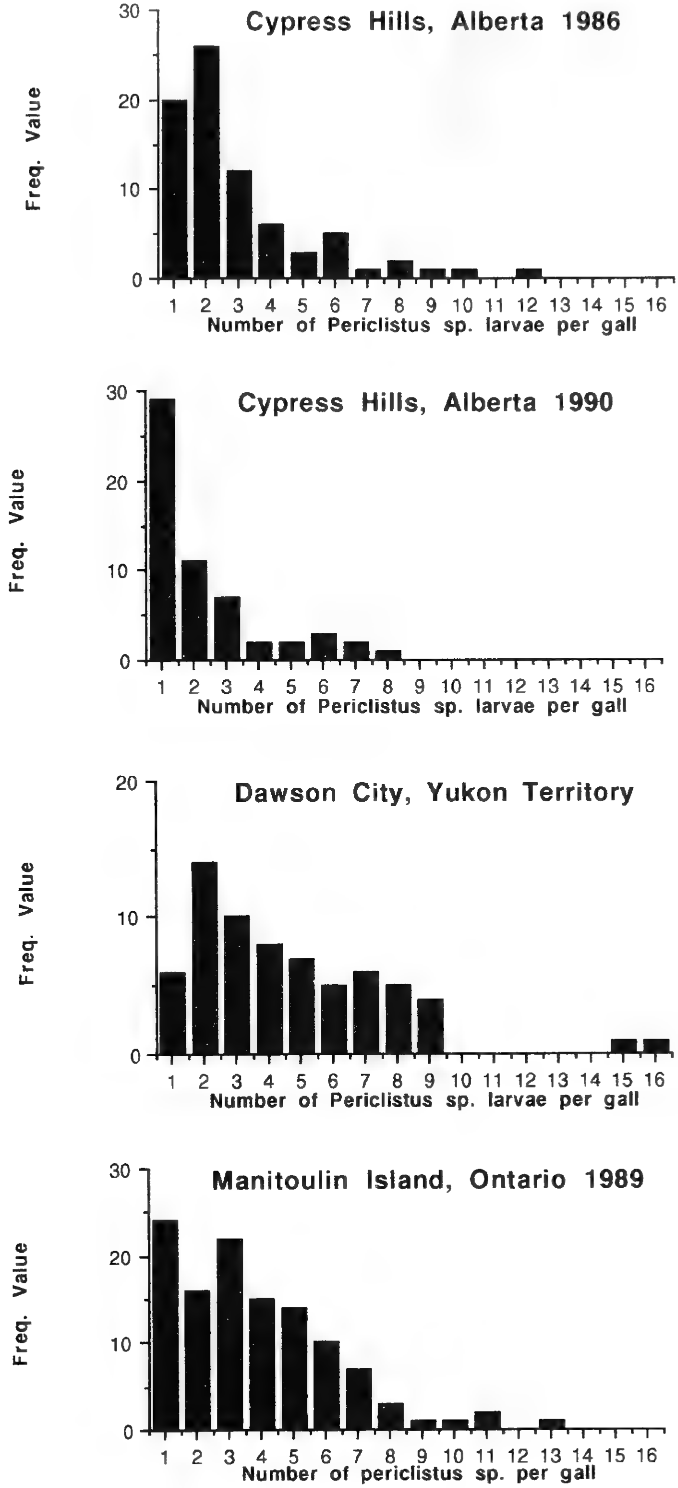

FIGURE 5. Frequency distributions for number of *Periclistus* sp. larvae in galls of *Diplolepis polita* found in various localities.

Washburn and Cornell 1981; Stille 1984), it appears that composition of the Cypress Hills *D. polita* community is influenced more by weather. Although supplied with more precipitation than the surrounding prairies, I suspect that cooler temperatures, particularly in the spring, delay gall development. Of interest, more immature galls were found in August of 1986 and 1990 in the Cypress Hills than occur in habitats on this date in northern Alberta and the central Yukon. All larvae of *D. polita* and *Periclistus* sp. are mature by mid-August from central Yukon to southern Ontario whereas in the Cypress Hills, many of the inducers and inquilines will not mature by the end of season. The presence of *D. polita* in 24.6% of the mature 1986 galls would have been more than adequate to populate the area in 1987 and yet the population crashed, whereas in other areas, the occurrence of *D. polita* in less than 5% of the galls allows a large population to exist from year to year. The smaller populations of parasitoids and inquilines in the Cypress Hills galls, along with the size of *Periclistus* -modified galls and the number of *Periclistus* larvae per gall also is an indication of harsher weather conditions interfering with gall location and oviposition success by these species.

The Cypress Hills population of *D. polita* may have been part of a continuum across southern Alberta during the cool period following glaciation, but became isolated along with its host plants when the prairies between the hills and the mountains became more arid. Or, the adult *D. polita* responsible for the large population of galls in 1986 may have been carried across the prairies from the moister river valleys and foothills to the west by the frequent and strong westerly winds. *Diplolepis* adults have amazing powers of dispersal and host location as has been shown by recent studies of stem-gall inducers moving from wild to urban roses (Shorthouse 1988).

Acknowledgments

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Seabirds and Marine Mammals Recorded in Western Hecate Strait, British Columbia, in Spring and Early Summer, 1984-1989

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Gaston, Anthony J., and Ian L. Jones. 1991. Seabirds and marine mammals recorded in western Hecate Strait, British Columbia, in spring and early summer, 1984-1989. Canadian Field-Naturalist 105(4): 550–560.

We made systematic observations of marine birds and marine mammals in the vicinity of Reef Island, in the Queen Charlotte Islands, in April-June of 1984-1989. Our sightings extend considerably the information available on the occurrence of seabirds in Hecate Strait. The frequency of sightings and numbers of individuals involved varied widely from year to year for non-breeding visitors, especially Sooty Shearwaters, Herring Gulls and Black-legged Kittiwakes. These fluctuations appeared to be related to the local abundance of euphausiid crustacea. Sightings of offshore-feeding seabirds occurred especially during periods of strong south-east winds, associated with the passage of depressions.

Key Words: Seabirds, marine mammals, Hecate Strait, inter-year variation.

Although little studied, Hecate Strait has an abundance of marine birds and mammals. It is the probable foraging area for twelve species of locally breeding seabirds. Their combined populations total more than half a million birds (Rodway 1990). It is also used by thousands of migrating and wintering loons, shearwaters, phalaropes, gulls and auks. Marine mammals are also abundant, although probably much less so than in the past. Knowledge of the marine birds of Hecate Strait is poor (Campbell et al. 1990), with only sporadic sightings, except for periodic boat surveys carried out in 1976 and 1977 (Vermeer et al. 1983), and in 1983 and 1984 (Vermeer and Rankin 1984), and limited aerial surveys in the fall and winter of 1977 to 1978 (Savard 1979). No information is available on year-to-year variation in seabirds and marine mammals using the area.

Study Area and Methods

Hecate Strait separates the Queen Charlotte Islands archipelago from the mainland of British Columbia. It is connected broadly to the Pacific via Queen Charlotte Sound in the south, and more narrowly, through Dixon Entrance, to the north. The strait is mainly more than 200 m deep at the southern end, but shallows rapidly in the centre, with two deeper channels running up the east and west coasts (Figure 1). To the east of Graham Island, shallow banks create large areas less than 40 m deep. Coasts are mainly rocky, but approaching Dixon Entrance they are sandy or muddy, with long bars reaching offshore (Sandspit, Rose Spit).

During 1984 to 1989, the Canadian Wildlife Service maintained a camp on Reef Island, on the east side of the Queen Charlotte Islands, to conduct research on Ancient Murrelets, *Synthliboramphus antiquus*. While this work was in progress, we made regular observations of marine birds and mammals in the adjacent waters of Hecate Strait. Reef Island is the furthest island from the rest of the archipelago, and water more than 100 m deep occurs within 1 km of the eastern tip. The deep water forms the northernmost branch of a submarine canyon which extends up the east coast of the Moresby archipelago. Tidal currents in the area of Reef Island set northwards during the flood, reversing during the ebb. Velocities offshore are of the order of 0.5 m s^{-1} (Thomson 1981). The island's exposed position, and the proximity of deep water, make Reef Island a useful platform for observing pelagic birds which are not seen otherwise near to land (Figure 2).

Observations from Reef Island were made with a 25× spotting scope from a lookout point about 15 m above the sea, in the middle of the north coast. At least one watch, for a minimum of 15 min, was made daily between 0900–1300 h, and additional watches were made at other times of day when conditions and time allowed. At times of heavy seabird passage, or high marine mammal activity, several watches were made throughout the day. Additional observations were made during periodic boat trips around Reef Island, up to 10 km east into Hecate Strait and as far north as Skedans Islands. The periods covered by observations were 13 April to 22 June 1984, 6 April to 15 June 1985, 10 May to 14 June 1986, 22 April to 17 June 1987, 30 March to 20 June 1988 and 23 March to 16 June 1989. Our daily observations were usually brief, and made only when other work permitted, but they provide comparable data for May and June for six years and for April for four years. Hence they provide the first indication of how predictable the occurrence of various species may be.

In the species accounts that follow, we have used several local place names that do not appear on maps or charts of the area in order to describe previously

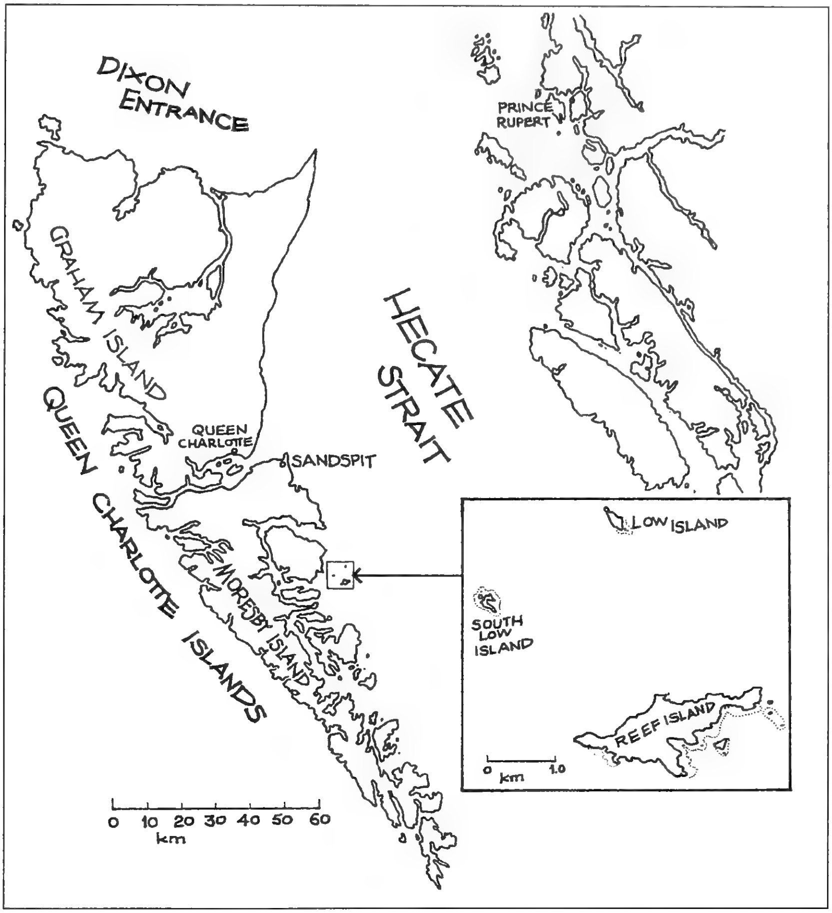

FIGURE 1. Map of Hecate Strait, showing bathymetry and the position of Reef Island.

unnamed features (Figure 2). Observations of birds within 500 m of Reef Island are described as, "off Reef Island". Birds to the north of Reef Island, but south of Low Island, are described as in "Low Island Sound". Those seen from the lookout to the east or northeast of Low Island are so described, while any described as "between Low Island and Skedans Islands" or "in Hecate Strait" were seen on boat trips up to 10 km east and north of Reef Island. Observations made in inshore waters (<1 km from shore) away from Reef Island are excluded, except for a few involving unusual species or numbers. All observations referring to rates of passage were made from the camp lookout and were based on counts of from 10 to 30 minutes duration. For comparison, all have been converted to birds/h. We used the following classification to categorize abundance: *Abundant*: seen on at least 50% of days, often in large numbers; *Common*: at least one seen on more than 50% of days; *Uncommon*: seen on more than five dates, but on less than 50% of days of observations; *Rare*: seen on five dates or less. Wherever the status observed in the Reef Island area differed from that given in *The Birds of British Columbia* (Campbell et al. 1990) we have drawn attention to it.

Results

Species Accounts: Birds

RED-THROATED LOON, *Gavia stellata*.

Rare migrant. Single birds in summer plumage off Reef Island on 29 and 31 May 1985 and 30 May 1987. The species is resident on Graham Island (Campbell et al. 1990).

PACIFIC LOON, *Gavia pacifica*.

Abundant migrant. Recorded regularly in all years, from early April, but highest numbers occurred in May, when a steady northwards passage was discernable, except when unfavourable weather conditions altered the direction of movement. Peak numbers were: in 1984, 31 May, 100/h moving north; 1985, 15 June, 100–150 between Skedans and

Limestone Islands; 1986, 13–25 May, "small numbers" moving north; 1987, 1 May, 150 in Low Island Sound; 1988, 14 May, 200 in Low Island Sound, 15 May, 600/h moving south; 1989, 24 May, 60 in Low Island Sound. Most birds seen from the beginning of May onwards were in summer plumage.

COMMON LOON, *Gavia immer*.

Migrant. Common, in small numbers, up to the middle of May in all years; uncommon thereafter. In 1985 several dozens were present in Low Island Sound during 25 April to 15 May. Most birds seen in April were in winter plumage. In May, some were in summer plumage, and some half-and-half.

YELLOW-BILLED LOON, *Gavia adamsii*.

Rare. Singles were seen on 12 May and 13 June 1985, 30 May 1986 and 28 March 1989. On 31 May 1985 one in breeding plumage was found dead several kilometres offshore.

RED-NECKED GREBE, *Podiceps grisegena*

Common in small numbers in April in some years. One or two were present off Reef Island throughout April in 1984, 1985 and 1988, but there was only one record in 1987, on 1 May, and one in 1989, on 23 March. There were only two other records in May, both in 1984. All were in winter plumage.

WESTERN GREBE, *Aechmophorus occidentalis*.

Single birds were seen off Reef Island on 17 April 1988 and 23 April 1989. Large flocks occur in the inlets of the Moresby archipelago in winter and spring (Savard 1979). In Thurston Harbour, Talunkwan Island, 150 were present on 29 March and 11 April 1988, while 400 were seen in Selwyn Inlet on 12 April 1989.

BLACK-FOOTED ALBATROSS, *Diomedea nigripes*.

Rare visitor. Singles passed northwards with heavy movements of shearwaters on 14 May 1985 and 1 April 1989. This albatross is common in spring and summer off the west coast of the Queen Charlotte Islands, but few are observed in Hecate Strait, except during or after storms (Campbell et al. 1990).

NORTHERN FULMAR, *Fulmarus glacialis*.

Uncommon migrant. Small numbers were recorded during 17 to 30 May 1986, including one feeding on a floating sealion carcass off Reef Island. Five, all dark-phase, passed south on 30 March 1989.

SHEARWATERS, *Puffinus* spp.

We have lumped all species together, because many of them were seen at several kilometres range, making specific identification difficult. We regularly examined shearwaters seen close inshore to check for the presence of Short-tailed Shearwaters, *Puffinus tenuirostris*, which have been reported in May in Hecate Strait (Campbell et al. 1990), but none were identified. Consequently, we believe that all the small dark shearwaters observed were Sooty Shearwaters, *Puffinus griseus*. Pink-footed Shearwaters, *Puffinus creatopus*, which have pale underparts, were identified only in 1985, when one on 24 May and about twelve on 28 May passed southwards, with larger numbers of Sooty Shearwaters. The large, all-dark Flesh-footed Shearwater, *Puffinus carneipes*, may be a rare visitor, as it occurs in summer in Queen Charlotte Sound (Campbell et al. 1990). Three very large, dark shearwaters flying south with Sooty Shearwaters on 15 May 1988 were probably of this species.

Sooty Shearwaters, *Puffinus griseus*, were common, sometimes abundant, non-breeding visitors. They were recorded from 26 March to 17 June, often in very large numbers, but very unpredictable. Typically, large numbers occurred in association with low pressure systems which brought east or south-east winds to Hecate Strait. Under these conditions rates of movement observed to the east of Reef Island exceeded 5000 birds/h on 21 May 1984, 18 to 23 May 1986, 26 May 1988, 1 April and 13 June 1989. On 23 May 1986 and 13 June 1989 more than 10 000 birds/h were moving south at the peak. Combining data for all years, movements involving more than 100 shearwaters/h passing to the east of Reef Island occurred on 32% (n = 107) of days with winds of more than 10 km/h from the east, or south-east, but on only 5% (n = 188) of days with winds from other quarters (Figure 3). Most of the large movements were southwards, into the wind, and often in bad weather, with low visibility. Under such conditions, shore-based observers presumably saw only a small proportion of the birds passing. Many were probably passing too far out to be counted. Hence, rates of movement of more than 5000/h, which continued all day on several occasions, presumably indicated the presence of hundreds of thousands of shearwaters in Hecate Strait.

On several occasions large feeding flocks occurred within sight of Reef Island, to the northeast. In 1985, 10 000+ were present on 28 to 30 April. On 14 May, 100 000 were estimated present at 1130 hrs and by 1700 hrs this had risen to between a quarter and a half a million. Rafts of up to 30 000 continued to be present in the same area until 2 June. In 1986, several thousand were present from 26 to 28 May and in 1988 1000–2000 were present on 31 March and "hundreds" on 19 May. Five thousand were present between Reef Island and Skedans on 15 June 1989. No significant feeding flocks were seen in 1987, when only small numbers were recorded before 31 May. Our counts of Sooty Shearwaters are the largest recorded in British Columbia, except for a flock of half a million off Ramsay Island, 30 km south of Reef Island, on 2 May 1977 (Campbell et al. 1990). A flock of about 10 000 was seen 8–10 km

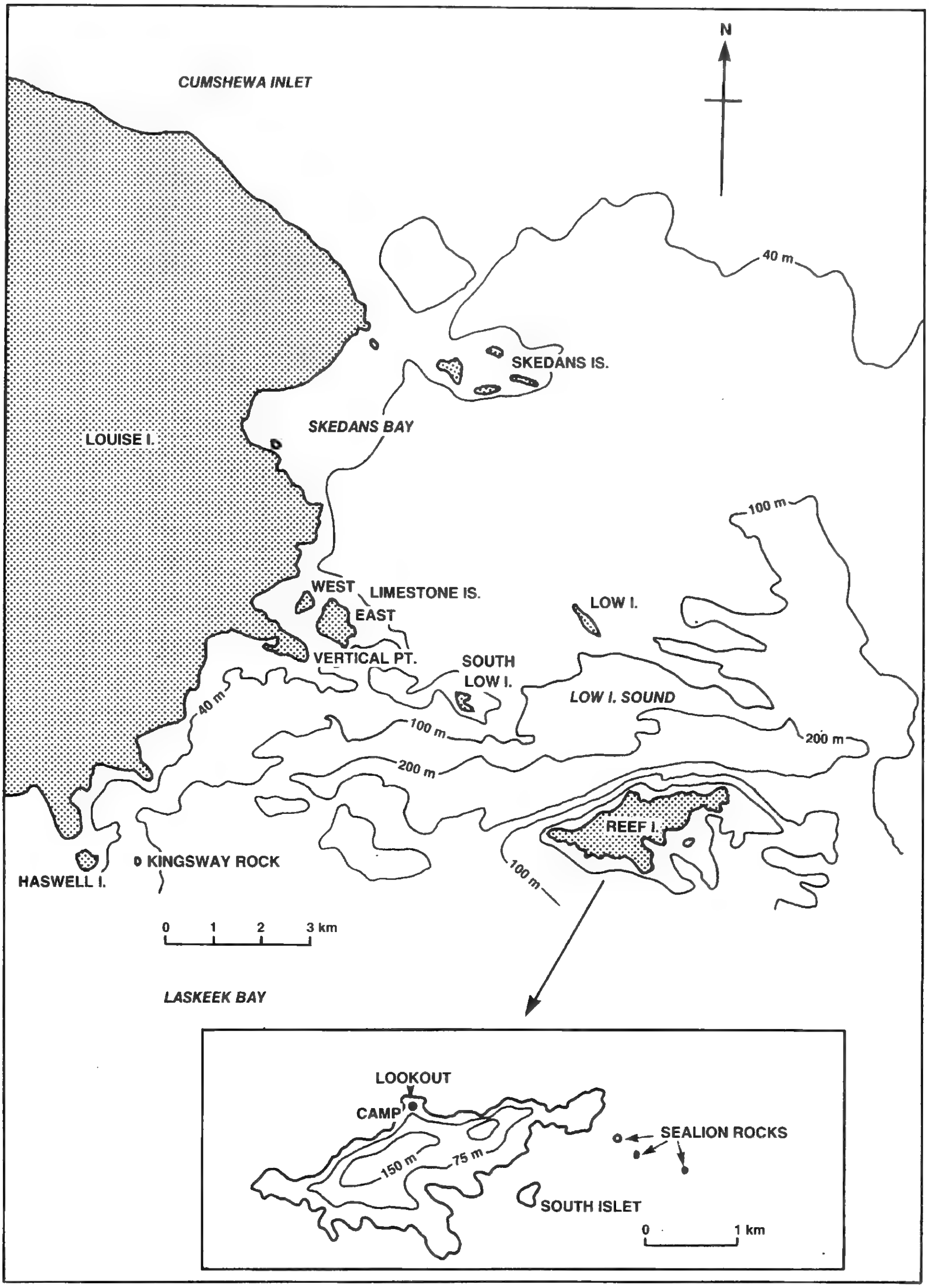

FIGURE 2. Map of Reef Island and adjacent waters.

east of East Copper Island on 15 May 1985 (M. Lemon and M. Rodway, Canadian Wildlife Service, P.O. Box 340, Delta, British Columbia, personal communication). Shearwaters, probably Sooties, have been recorded in small numbers in Hecate Strait throughout the winter (Savard 1979).

In 1985, close examination of feeding flocks showed that they were feeding on swarms of euphausiid crustacea, taking them either by diving from the surface and swimming underwater, or by hydroplaning along the surface, with wings flapping, heads underwater and bills agape. Similarly, in 1989,

feeding flocks were closely associated with swarms of euphausiids.

Many birds present in 1985 and 1989 were undergoing primary moult, showing clear gaps where one or more inner primaries were missing. The tideline at Reef Island in May 1985 was littered with thousands of moulted shearwater primaries. In 1989, no signs of moult were visible on birds examined up to 11 April, but many of those seen feeding in the second half of May had lost their inner primaries. Hence primary moult began in late April.

FORK-TAILED STORM-PETREL, *Oceanodroma furcata*.

Several hundred pairs breed on Low Island and some also on the islet off the south coast of Reef Island (Rodway et al. 1988). A few were heard calling and seen displaying over a rocky bluff on the south side of Reef Island on several dates in 1986, 1987, and 1988. Seldom seen offshore, except during strong south-east winds when small numbers were sometimes seen passing through Low Island Sound. On 13 May 1985, five were seen feeding in Low Island Sound.

LEACH'S STORM-PETREL, *Oceanodroma leucorhoa*.

This species breeds on Lost Islands, 8 km south of Reef Island (Rodway et al. 1988). One was mist-netted on Low Island on 6 May 1986, but although they must occur in offshore waters, only one was ever seen by day from Reef Island.

DOUBLE-CRESTED CORMORANT, *Phalacrocorax auritus*.

Uncommon non-breeding visitor. Up to five seen around Reef Island on seven dates in 1985, two in 1986, one in 1987 and four in 1988. Commoner in 1989 when up to five were present on five dates in March, 14 in April and 6 in May.

BRANDT'S CORMORANT, *Phalacrocorax penicillatus*.

Uncommon non-breeding visitor. Seen occasionally every year in small numbers. Maximum counts were on 23 April 1985, when fifteen were present on Sealion Rocks, and on 15 May 1986 when 29 flew south in groups of two to four. Most birds were in immature plumage, but on 6 April 1988 there were six in breeding plumage near the eastern tip of Reef Island. Campbell et al. (1990) considered this species a vagrant in the Queen Charlotte Islands.

PELAGIC CORMORANT, *Phalacrocorax pelagicus*.

Common non-breeding visitor, breeds in some years. A small breeding colony near the east end of Reef Island, one of only three in South Moresby (Rodway et al. 1988), was occupied in 1985 and 1986, when a minimum of ten and eleven pairs nested. In 1985 four clutches were being incubated on 13 June, and in 1986 three clutches were being incubated on 31 May. In 1987 to 1989 up to 350, of which more than 90% were in immature plumage, roosted regularly on the south coast of Reef Island, but no

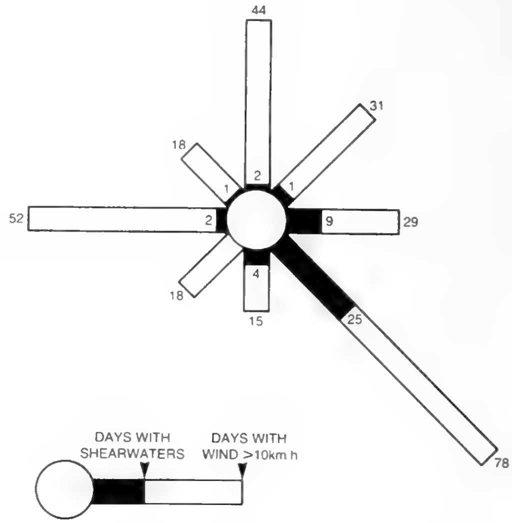

FIGURE 3. The occurrence of days with a heavy passage of shearwaters, in relation to wind direction.

evidence of breeding was found. Roost birds commuted daily to inshore waters in Laskeek Bay and at the mouth of Cumshewa Inlet.

BALD EAGLE, *Haliaeetus leucocephalus*.

Common resident and non-breeding visitor. Five or six pairs were resident on Reef Island in all years, and another on South Islet, just off the south coast. During May large numbers of non-breeders, the majority in adult plumage, occurred in the area roosting either on the Skedans Islands, Low Island, or Reef Island. Maximum counts were 75 on Low Island on 22 May 1985, 100 on Reef Island and 45 on Low Island on 14 June 1987, 100+ on Low Island and several dozen on Reef Island on 31 May 1988 and 150 on Low Island on 9 May 1989. These concentrations are larger than any reported in spring or summer by Campbell et al. (1990). Large gatherings were always associated with the presence of herring shoals offshore.

RED PHALAROPE, *Phalaropus fulicarius*.

Rare migrant. A flock of about 250 was seen during a strong south-east gale on 7 May 1984.

RED-NECKED PHALAROPE, *Phalaropus lobatus*.

Uncommon migrant. Flocks were seen feeding to the north-east of Reef Island in May in 1985, 1986 and 1989. Highest counts were 250 in Low Island Sound on 18 May 1985, and 150 to the east of Low Island on 17 May 1989. Flocks totalling 400 flew north off Reef Island on 10 May 1989. All were in breeding plumage.

POMARINE JAEGER, *Stercorarius pomarinus*.

Uncommon migrant. One or two were seen in Hecate Strait on 31 May and 9 June 1985, 18 and 22

May 1986, and 25 May, 2 June and 15 June 1989. All but the last bird were in adult, pale-phase plumage.

PARASITIC JAEGER, *Stercorarius parasiticus*.

Rare migrant. One or two pale-phase adults in Hecate Strait on 31 May and 9 June 1985, 24 May 1986 and 22 May 1989.

SOUTH POLAR SKUA, *Catharacta maccormicki*.

Rare migrant. One "skua species" seen from Reef Island on 3 June 1987, was presumably of this species. Apart from this record, the earliest reported for British Columbia is 13 June. There is one previous summer record from Hecate Strait (Campbell et al. 1990).

MEW GULL, *Larus canus*.

Rare visitor. One, near Reef Island, on 27 April 1984 and 7 May 1985. The species is common in winter in the Queen Charlotte Islands (Campbell et al. 1990).

CALIFORNIA GULL, *Larus californicus*.

Uncommon non-breeding visitor. Small numbers were recorded occasionally in all years, with a maximum of 40 present in Low Island Sound on 8 May 1984. One immature was picked up dead in Laskeek Bay on 15 May 1988. Like Thayer's Gull, this species may have been overlooked sometimes among Herring Gulls. Campbell et al. (1990) characterised the species as casual in the Queen Charlotte Islands in spring and summer.

HERRING GULL, *Larus argentatus*.

Common in all years, but numbers were extremely variable. In 1984, only small numbers were seen in April and on one date in May. In 1985, hundreds, practically all immatures, were present in Low Island Sound during 27 April to 2 May. In 1986, up to 20 were recorded almost daily in May and June. In 1987, large numbers, practically all immatures, were present around Reef Island from 29 April to 23 May, with peaks of 4000 to 5000 on 30 April, 'thousands' on 5 May and 500 to 1000 on 15 May. Although there were generally less than a hundred present after 23 May, 500 to 1000 were present on 1 June. In 1988, small numbers were recorded throughout the season, but up to 3000 were feeding east of Low Island on 10 April and 500 on 2 May. On 2 April 240/h and on 15 May 600/h were moving south off Reef Island. A similar pattern was seen in 1989, when hundreds of immatures were present from 24 April to 25 May, with peaks of 1500 on 1 May and 2500 on 14 May. Up to 500 roosted on Sealion Rocks throughout the period.

THAYER'S GULL, *Larus thayeri*.

Uncommon migrant (?). The status of this species is unclear, because it could only be identified with certainty at close range, and some individuals seen at a distance must have been overlooked. Small numbers were recorded in all years in April and up to 17 May. The maximum number recorded was 12 on Sealion Rocks on 23 April 1984. Most of those seen were with flocks of Glaucous-winged Gulls and Herring Gulls roosting on the Sealion Rocks.

GLAUCOUS-WINGED GULL, *Larus glaucescens*.

Common resident. Breeds on Low Island and Kingsway Rock, and a few pairs generally nest on the Sealion Rocks. Rodway et al. (1988) recorded 18 colonies exceeding 10 pairs in the South Moresby area.

Breeding on Low Island was apparently disrupted in 1987 by large numbers of Bald Eagles roosting in the colony area. At least 15 nests were built, or refurbished, and laying had begun at several by 5 June. However, on 14 June 40 eagles were perched in the area and no gulls were incubating. Likewise, in 1989 there was probably no breeding on Low Island. Thirty pairs were present on 27 June, and at least ten nests had been built, but no eggs were found. Laying on Low Island began about 10 June 1984, 30 May 1986, 5 June 1987 and 8 June 1988.

Large flocks of immatures were present in the area occasionally. Two hundred were present on Low Island on 9 June 1985 and "hundreds" on Sealion Rocks on 3 June 1987. Flocks of less than 100 immatures fed on herring shoals throughout May in 1989, along with adult Glaucous-winged Gulls and immature Herring Gulls.

GLAUCOUS GULL, *Larus hyperboreus*.

Rare visitor. One, in all white, second summer plumage, was seen on 19 May 1984.

BLACK-LEGGED KITTIWAKE, *Rissa tridactyla*.

Common, sometimes abundant, non-breeding visitor. Not recorded in 1984, and seen on only three dates in 1986, but very common in other years, although numbers seen after April varied greatly. In March and April the majority of birds seen were in breeding plumage, but in May and June immatures made up more than 90% of those observed in all years.

In 1985, kittiwakes were very common from 21 April to 25 May, with more than 10 000 present to the northeast of Reef Island on 13 to 14 May. On 9 June, 200 were present on Low Island and 1000 between there and Skedans Islands, all immatures. In 1986, only small numbers were seen, on 12, 13 and 25 May. In 1987, hundreds of immatures were present throughout May, but no more than 15 were seen after 1 June. In 1988, up to 1000 were present in Low Island Sound up to 10 April, but the only record otherwise was of 20 immatures in Hecate Strait on 19 May. In 1989, adults were very numerous throughout April, with up to 5000 present in Low Island Sound. Hundreds of immatures continued to

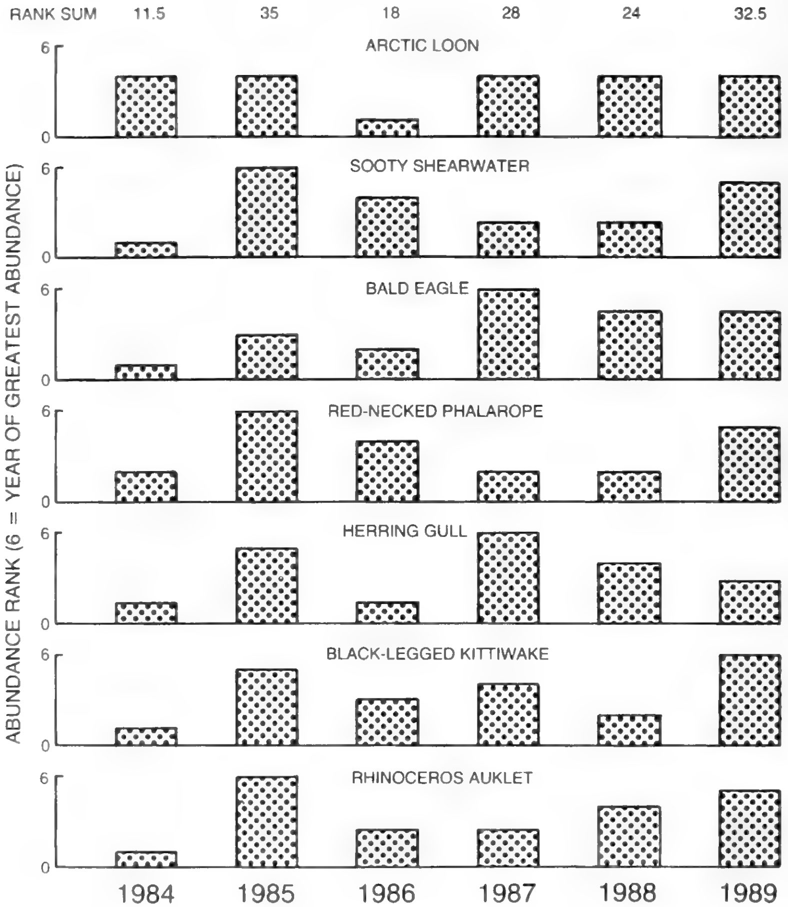

FIGURE 4. The relative abundance of selected seabird species in Hecate Strait over six years.

be present in the area until 15 June. These numbers exceed those recorded anywhere else in British Columbia (Campbell et al. 1990).

SABINE'S GULL, *Xema sabini*.

Uncommon migrant. Seen in Hecate Strait on four dates between 2 to 18 May in 1985, on 19 May 1986 and 19 May 1988. The largest number seen was a flock of 30 to 40 feeding with Black-legged Kittiwakes on 3 May 1985. All were in breeding plumage

ARCTIC TERN, *Sterna paradisaea*.

Uncommon migrant. Terns, probably of this species, were seen on 19 May 1984, when 25 flew east off Reef Island and on 24 May 1989, when two flew north. Campbell et al. (1990) do not list any sightings for Hecate Strait.

COMMON MURRE, *Uria aalge*

Uncommon non-breeding visitor. Seen in small numbers, practically throughout the season, in all years. Most common in 1988 when hundreds were present in Hecate Strait in groups of 6–20 on 12 April. The majority of these were in winter plumage. On 16 May 1988, a southward movement of 100/h was seen. Several thousand pairs of Common Murres breed at Triangle Island in Queen Charlotte Sound (Rodway 1990).

THICK-BILLED MURRE, *Uria lomvia*.

Rare non-breeding visitor. We observed three 5 km NE of Reef Island on 8 May and one on 30 May 1985. Others may have been overlooked among Common Murres. There are no other spring records for British Columbia (Campbell et al. 1990).

PIGEON GUILLEMOT, *Cepphus columba*.

Common resident. Breeds on practically all islands in the area, including Reef and Low islands (Rodway et al. 1988). Maximum counts of birds attending nesting areas on Reef Island were: 1984, 280 on 6 June; 1985, 338 on 30 May; 1988, 400 on 1 April; and 1989, 563 on 30 April. In 1989, counts

made in April were higher than those in May or June, perhaps because some birds moved out of the area as the season progressed.

MARBLED MURRELET, *Brachyramphus marmoratus*.

Uncommon resident. This species occurs commonly in inshore waters around the Queen Charlotte Islands during the breeding season, and is presumably a common breeder (Campbell et al. 1990). At Reef Island it was recorded in small numbers in all years, mainly from May onwards. Highest numbers were seen in 1987 when maxima of 20, 26 and 35 were recorded off the south coast in June. None was ever seen on passage.

ANCIENT MURRELET, *Synthliboramphus antiquus*.

Common resident, breeding on Reef and Limestone islands, and perhaps on Low Island. The Ancient Murrelet has been the subject of detailed research at Reef Island and the results have been published elsewhere (e.g., Gaston et al. 1988; Jones et al. 1990). About 5000 pairs breed on Reef Island (Rodway et al. 1988), and the birds associated with this colony stage in Low Island Sound from mid-afternoon onwards when the sea conditions permit. Most birds apparently feed well offshore in Hecate Strait, because many flocks are seen heading eastward, away from the staging area, in the morning. Family parties stay well offshore after leaving the colony (Duncan and Gaston 1990). Up to a few hundred were seen feeding in Low Island Sound and between Low Island and Skedans Islands in May and June, especially in 1985 and 1989. No substantial passage of murrelets was ever seen.

CASSIN'S AUKLET, *Ptychoramphus aleuticus*.

Common resident. Breeds commonly on most islands in the area, including Reef Island and Low Island (Rodway et al. 1988). Small numbers were observed in Hecate Strait and Low Island Sound on most boat trips. On 5 June 1984 "hundreds" were feeding between Reef Island and Skedans Islands; on 9 June 1985, several hundred were present in the same area.

RHINOCEROS AUKLET, *Cerorhinca monocerata*.

Common visitor, probably breeds. The nearest substantial colony is on Kunghit Island, 90 km to the south (Rodway et al. 1988), but up to 100 were seen in Low Island Sound on most evenings in May and June, and birds were heard calling from land on many occasions. A few burrows were located on Reef Island in 1977, by a crew from the British Columbia Provincial Museum (B.C. Provincial Museum files; now Royal British Columbia Museum). Though we never found any, it seems almost certain that some must continue to breed on Reef Island.

Large numbers were seen feeding in Hecate Strait and north of Low Island in 1985 and 1989. On 5 June 1985, "hundreds" were feeding in Low Island Sound and on 9 June, 1000 to 2000 were feeding between Low Island and Skedans Islands in flocks of up to 100. In the late afternoon many were carrying fish, presumably to feed to chicks that night. From the number involved they could not have originated from Reef Island, and hence must have been commuting from the colonies at Kunghit Island (2500 pairs, Rodway et al. 1988), or in the Moore Islands – Byers Islands group, on the east side of Hecate Strait (>90 000 pairs, M. Lemon personal communication). On 22 May 1989, 200 were seen in Hecate Strait and 100 in Low Island Sound, and on 25 May and 2 and 15 June, "hundreds" were feeding in Hecate Strait. Heavy passage was seen to the east of Reef Island on 15 and 24 May 1988, when 1200/h and 600/h were flying south.

TUFTED PUFFIN, *Fratercula cirrhata*.

Uncommon. One or two seen on two dates in June 1984, two in April, three in May and five in June in 1985, two in May in 1986, two in April in 1988, and two in June in 1989. The nearest breeding colony is on Kunghit Island (Rodway et al. 1988).

HORNED PUFFIN, *Fratercula corniculata*.

Rare. Single birds seen on 9 June 1984, on 11 May and 13 June 1985, on 3 April 1988 and on 30 March 1989. The nearest breeding station is on Anthony Island (Rodway 1990).

Species Accounts: Marine Mammals

HUMPBACK WHALE, *Megaptera novaeangliae*.

Up to three were seen almost daily from 2 to 14 May 1985, and on four dates thereafter, the latest being 6 June. One was seen on 17 May 1987. In 1989, up to three were seen to the north and east of Low Island on five days between 14 to 23 May. On 25 May, about five were present in Hecate Strait to the northeast of Low Island.

FIN WHALE, *Balaenoptera physalus*.

One or two were seen daily from 3 to 8 May 1985. In 1989, two were seen to the northeast of Low Island on 20 May, and several spouts which looked like those of this species were seen in Hecate Strait on 25 May.

MINKE WHALE, *Balaenoptera acutorostrata*.

Singles were seen on 28 April 1984, on four dates in April and three in May 1985, on 17 May 1986, and on 29 May 1989.

KILLER WHALE, *Orcinus orca*.

Pods of up to 12, presumably transient, were seen from Reef Island on 8 May 1984, 30 April 1985 (8–10), 14 May 1986 (12), and 22 May (4) and 13 June 1989 (4).

HARBOUR PORPOISE, *Phocoena phocoena*.

A pod of about 10 was seen between South Low Island and Vertical Point on 8 May 1988.

PACIFIC WHITE-SIDED DOLPHIN *Lagenorhynchus obliquidens*.

Small numbers were seen in Low Island Sound on 1 and 8 May 1984, on 14 and 15 May and 3 June 1985, and on 22 May 1989.

DALL'S PORPOISE, *Phocoenoides dalli*.

Several were seen in Low Island Sound on 11 and 12 May, and two on 9 June 1985. Two were seen on 14 and 16 June 1987. In 1989, one was seen on 22 April, four on 22 May and at least four on 31 May.

HARBOUR SEAL, *Phoca vitulina*.

Regular haul-outs occur on Low Island, where up to 40 animals were seen, including small pups, and on the south coast of Reef Island, where up to 15 were recorded.

NORTHERN ELEPHANT SEAL, *Mirounga angustirostris*.

One male was seen on 13 April 1988. In 1989, a single male was recorded on 25 and 28 March, 1 and 23 April, and 3 and 4 May.

STELLER'S SEALION, *Eumetopias jubatus*.

A regular, year-round haul-out is situated on the Sealion Rocks, just to the south-east of Reef Island. It was never without animals, when visited. Counts were made on 11 June 1988 (200), and in 1989 on 29 March (455), 5 April (425), 17 April (445), 30 April (240), 1 May (150), 2 June (100), and 27 June (210). On 2 May 1989 there were 25 hauled out on the easternmost Skedans Island.

NORTHERN FUR SEAL, *Callorhinus ursinus*.

One seen moving north between Lost Islands and Reef Island on 30 May 1985.

Discussion

Observations made at Reef Island considerably extend the information available on seabirds in Hecate Strait. The regularity with which we recorded Sooty Shearwaters and Black-legged Kittiwakes, and the large numbers involved, suggest that Hecate Strait is an important non-breeding area for both species. Black-legged Kittiwakes present after the end of April were nearly all in immature plumage. These birds presumably originated from the large colonies in Alaska (Sowls et al. 1978). Counts of Sooty Shearwaters suggest that in good years there were a minimum of several hundreds of thousands present in Hecate Strait, and sometimes many more. Vermeer and Rankin estimated over 4 million Sooty Shearwaters in Hecate Strait and Queen Charlotte Sound in May 1983, compared to only 145 000 in the same month of 1982, and only 15 000 in April 1984. Likewise they estimated 1600 Black-legged Kittiwakes in Hecate Strait in May 1982, 9500 in May 1983, but only 136 in April 1984. In the latter year, we saw none at all. The magnitude of the variation seen by Vermeer and Rankin accords with the year-to-year fluctuations seen at Reef Island.

Briggs and Chu (1986) noted that numbers of Sooty Shearwaters off California were lower in May 1983 than in earlier years, presumably as a result of the intense El Nino event of that year. They suggested that the large numbers recorded by Vermeer and Rankin could have been birds displaced from California. However, our observations suggested that large numbers of Sooty Shearwaters are a frequent feature of Hecate Strait, and are not necessarily dependent on events of the magnitude of the 1982–1983 El Nino.

The fact that many Sooty Shearwaters were moulting in May is consistent with observations by Brown (1988) off California. The same author found no moult among Sooty Shearwaters seen off Newfoundland at the same time of year. He suggested that most birds off Newfoundland were non-breeders which moulted before departing from the breeding grounds, whereas those moulting in the eastern Pacific were post-breeding adults. If this is true of birds seen in Hecate Strait in April, the migration from their breeding grounds must be very rapid, because the adults do not leave their australasian breeding grounds until early April (Lindsey 1986).

A striking feature of observations at Reef Island was the range of variation among years. This applied particularly to Sooty Shearwaters, Black-legged Kittiwakes, and Herring Gulls, all of which occurred in thousands in some years, and were either absent, or seen in only small numbers, in others. There seemed to be some correspondence between the numbers of various species seen, with the most variable species being very numerous in 1985, and 1989, and poorly represented in 1984 (Figure 4). The two years of highest numbers coincided with the presence of larger-than-usual numbers of baleen whales, with feeding flocks of Ancient Murrelets within sight of Reef Island, and with the sighting of large swarms of euphausiid crustacea. It seems likely that these events were connected, and that whales and seabirds were all attracted to the area by an above-average abundance of euphausiids. Sooty Shearwaters and Black-legged Kittiwakes were seen feeding heavily on euphausiid swarms in both years. In contrast, the numbers of Pacific Loons and Common Murres, presumably largely fish-eaters, seen feeding in the area, varied little from year to year, suggesting that these birds were less opportunistic in their foraging.

Although the run of years is still small, it is impossible not to be struck by the fact that, at least since 1983 (including the observations of Vermeer and Rankin (1984)), numbers of Sooty Shearwaters and Black-legged Kittiwakes in Hecate Strait appear to have been high and low in alternate years. In

1990, as in previous even years, numbers of both species were low in the Reef Island area, and kittiwakes were not recorded at all in March-June (Laskeek Bay Conservation Society *unpublished*). At present no oceanographic phenomenon has been found to account for such a two-year periodicity.

Because Reef Island is the only station in Hecate Strait where systematic observations have been made over several years, we have no way to know how representative our observations were of other areas around the South Moresby archipelago. However, several factors suggest that the area offshore from between Skedans Islands and Low Island is particularly attractive to feeding seabirds and marine mammals. Although we made our land-based observations in an arc from due east to a little north of west of Reef Island, the majority of feeding flocks of seabirds and sightings of large whales were either north or east of Low Island. Likewise, during boat trips into Hecate Strait, densities of feeding birds were usually higher north of Low Island than elsewhere. Moreover, although we made observations from the southeast coast of Reef Island on two or three dates in May each year, we never saw feeding concentrations of kittiwakes, gulls, or shearwaters in that area.

The trough of deep water which extends up the west side of Hecate Strait terminates just to the east of Low Island, with fairly abrupt narrowing and shallowing. Northward-flowing flood tides, meeting this rapid shallowing, may cause upwelling, bringing slow-swimming organisms, such as euphausiids, to the surface. Such an effect might account for the concentrations of surface, or near-surface feeders; shearwaters, kittiwakes and gulls, in that area. A concentration of surface feeding seabirds off Briar Island, Nova Scotia, created by a similar tidal upwelling mechanism, was described by Brown (1980).

The magnitude of inter-year variation in seabird numbers off Reef Island makes it difficult to generalize about their status in Hecate Strait. Presumably, in years when no large numbers of kittiwakes and shearwaters were recorded, these birds were uncommon in Hecate Strait. Even in good years, they were not always seen daily. The periodic occurrence of large numbers visible from Reef Island probably indicates that they were present continuously in Hecate Strait, but moved into and out of the waters adjacent to Reef Island in response to changes in weather conditions and local feeding opportunities. The presence of feeding flocks of passage migrants, such as phalaropes and Sabine's Gulls, in some years but not in others, likewise suggests that these species will feed in the area when conditions are good, but pass through without stopping when they are not. The unpredictability of seabird numbers, both within and between years, emphasizes the fact that we cannot rely on surveys made over a short period, or in only a single year, to provide an adequate basis from which to assess the impact of potential developments. This needs to be kept in mind in any future consideration of our information base for assessing the effects of offshore oil developments in Hecate Strait.

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Notes

Rediscovery of the Northern Dusky Salamander, *Desmognathus f. fuscus*, in Ontario

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The Northern Dusky Salamander, *Desmognathus f. fuscus*, was discovered in two small streams in the Niagara River Gorge area near Niagara Falls, Ontario, in 1989. Previously published references to this species in Ontario all trace to two reports, published in 1905 and 1943 respectively, but no verification of their accuracy exists.

Key Words: Northern Dusky Salamander, *Desmognathus f. fuscus*, Ontario, Niagara Falls, habitat, rare species.

The Northern Dusky Salamander, *Desmognathus f. fuscus*, is primarily a species of streams and seepages in the Appalachian Mountains of eastern North America. In Canada, the species' range is well documented in southern New Brunswick and Quebec (Logier 1952, Bleakney 1958; Logier and Toner 1961; Cook 1984; Conant and Collins 1991). It was included in the Ontario herpetofauna by Nash (1905) who remarked that it was "rare, has been taken in southwestern Ontario". Bishop (1943) gave the first specific locality for the province, including "Ontario, opposite Buffalo" in his range statement. Logier and Toner (1961) mapped the Bishop (1943) locality. Cook (1984) suggested habitat changes might explain the failure of many field searches in the area since 1960. Here, I document its rediscovery in the Niagara region, and describe its habitat.

Four *Desmognathus f. fuscus* (three transformed and one larva) were found in two adjacent seepages in the Whirlpool area of the Niagara River Gorge (43°07'25"N, 79°04'15"W) at 1000 h 23 April 1989 by Ken Towle and I. The larva and one of the transformed individuals were found beneath moss-covered stones in a small pool below a mossy trickling waterfall. The other two individuals were beneath stones in a seepage stream about 100 m from the first discovery. A transformed specimen, 39.0 mm snout-vent length (SVL); 64.6 mm total length (TL), lacking the tip of its tail, was deposited as a voucher in the Canadian Museum of Nature (NMC 31985). The site was revisited 30 April and 19 September 1989. Seven transformed, and two transformed and two larvae were located, respectively.

The seepage streams were located under closed canopy deciduous forest dominated by White Ash (*Fraxinus americanus*), Hop-hornbeam (*Ostrya virginianus*), Paper Birch (*Betula papyrifera*), Sugar Maple (*Acer saccharum*), White Oak (*Quercus alba*), and Alternate-leaved Dogwood (*Cornus alternifolia*). Both streams were visually clear, permanent, and fast-flowing on about a 30° slope, and contained numerous stones. All salamanders were found roughly halfway between the top of the Niagara Escarpment and the Niagara River.

Two transformed individuals were found at an additional locality (43°09'12", 79°02'10"W), at 1600 h on 5 June 1989 by Wayne Weller and I. They were beneath flat stones at a stream edge within the Niagara Gorge, 4 km east of the initial sites. One (36 mm SVL and 69 mm TL) was deposited in the Royal Ontario Museum (ROM 19613). This site was revisited 6 June and 24 August 1989; one transformed individual was seen on each occasion. This stream was also permanent, fast-flowing, on a 30° slope and under a closed canopy deciduous forest. Here the forest consisted of Sugar Maple, Black Maple (*Acer nigrum*), Manitoba Maple (*Acer negundo*), and American Basswood (*Tilia americana*).

During 1989, all streams along the entire Canadian side of the Niagara Gorge from Niagara Falls to Queenston were searched intensively without locating additional populations. Virtually all seepage areas in this upper section of the Niagara Gorge originate as surface runoff from the city of Niagara Falls. I also searched many other streams that descend from the Niagara Escarpment from Queenston to Vineland, Ontario. Several of these streams are clear and fast-flowing and thus appear to offer suitable habitat. Redback Salamanders, *Plethodon cinereus*, were found here, but no Northern Dusky Salamanders.

At the two sites where *Desmognathus* has been located, an amphipod *Gammarus pseudolimnaeus* is abundant. The latter has been found in only one stream where the salamanders appear to be absent. This close association could indicate that either the amphipod is an important food source for the sala-

FIGURE 1. A Northern Dusky Salamander, *Desmognathus f. fuscus*, found near Niagara Falls, Ontario, 23 April 1989. Photograph by James Kamstra.

mander or that both share some habitat requirement. The amphipod breeds in fast-flowing streams where water temperatures do not exceed 13°C (Williams and Moore 1982), but it is considered to be moderately tolerant of organic pollution (Hilsenhoff 1982).

The salamander populations from the first locality appear to be in the cleanest remaining seepages in the Niagara Gorge, based on water clarity, the presence of moss, and the lack of odour.

The Northern Dusky Salamander is readily distinguishable as belonging to the family Plethodontidae by the presence of a fine groove from the nostril to the lip (naso-labial groove) and from the two species in the family which have previously been collected in the area (Redback Salamander and Spring Salamander, *Gyrinophilus porphyriticus*) by its low number of costal grooves (14) and their robust build with hind legs markedly larger that the front ones. The only other Plethodontidae which occurs near the area with a similar build is the Mountain Dusky Salamander, *Desmognathus ochrophaeus*, which has been recorded from adjacent New York State (Bishop 1941) but this species has a rounded tail, not markedly knife-edged above at its base, and a mouth line which is sinuous, not straight (*see* Conant and Collins 1991).

Efforts to find further documentation for Bishop (1943) have been unsuccessful. Bishop's herpetological collections, together with his extensive literature card file on salamander distribution, were deposited in the Field Museum of Natural History after his death. Alan Resetar found neither specimens nor entry for an Ontario record in them (personal communication to F. R. Cook, 17 October 1990). Fred Schueler (personal communication) had enquired at both the New York State Museum and the Buffalo Museum as well as corresponding with a number of herpetologists familiar with the Buffalo area. None of his contacts had any records of Northern Dusky Salamanders from the Ontario side of the Niagara River. New York records are documented in Bishop (1941). Bishop (1927) noted that "During July and August 1921 many specimens were brought to the Buffalo Society of Natural Sciences field museum from streams near Buffalo, Creekside and Fancher camps". The "opposite Buffalo" locality in Bishop (1943) may be a lapsus, as the same statement is used in the distribution of the Spring Salamander. The latter is documented from this locality by a larvae, collected in 1877 and deposited in the Museum of Comparative Zoology (Dunn 1926; specimen also examined by F. R. Cook, personal communication).

An unpublished report by E. C. Teachout (personal communication to M. J. Oldham, 1989) mentions

several salamanders taken in the vicinity of Fonthill, Regional Municipality of Niagara, Ontario, in the 1940s. These were sent to C. E. Burt and identified as *Desmognathus fuscus*. Some of Burt's collections were deposited at the Museum of Natural History, University of Kansas, but John E. Simmons (personal communication) reports that there are no *Desmognathus* from Canada among them.

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Common Names Applied to the Long-finned Pilot Whale, *Globicephala melas*

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Four common names were used to describe one species of whale in an article published in the Yarmouth Register, Yarmouth, Massachusetts in 1846: *Tursiops truncatus*, *Mesoplodon* sp., *Grampus griseus*, and *Globicephala melas* were analyzed to determine which species was the one in question. *G. melas* is most probably the species to which the article is referring.

Key Words: Porpoise, bass porpoise, blackfish, cowfish, Cape Cod, Bottlenosed Dolphin, *Tursiops truncatus*, beaked whales, *Mesoplodon*, Risso's Dolphin, *Grampus griseus*, Pilot Whale, *Globicephala melas*.

The whale records retrieved from old newspaper accounts may appear trivial, but in reality contain valuable information which may contribute to our knowledge and understanding of whale life-history. These accounts are rare and often times misleading as to the particular species of animal described. This ancient reporting needs further attention so that we may begin to better understand whale life-history patterns in the present.

On Thursday, 1 October 1846, the following article appeared in the Yarmouth Register, Yarmouth, Massachusetts:

"PORPOISES. 44 porpoises were killed on the flats near Central Wharf in this town on Friday last and on Sunday, 28, making in all 72. Blackfish are frequently driven on shore, and it is very unusual to find them in so shoal water that they may be killed, either with clubs or pitch forks. It is supposed that they were in pursuit of bass and got caught on the flats by the ebb of the tide.

About 70 porpoises have also been killed on the flats in Barnstable Harbor. We have also learned that a school of over 500 came ashore at Brewster, on Friday, and were secured.

They are not the common porpoises which are frequently seen in our harbors but a larger variety, called the bass porpoise. Whalemen call them cowfish."

The use of common names can be very misleading. During the course of a study of the strandings of blackfish (*Globicephala melas*) on Cape Cod, it was imperative to be able to decipher articles such as the one above. This article was troublesome in that four common names, porpoise, blackfish, bass porpoise, and cowfish, were mentioned under the heading of "PORPOISES", apparently to describe one species.

Porpoise and blackfish frequently were used interchangeably to describe *G. melas*. The above reference was the only time that I came across "bass porpoise," and there appears to be no other mention of this name referring to any species in the literature. On the other hand, the name "cowfish" was used occasionally. Beddard (1900) describes *Tursiops gillii* (now *T. truncatus*) as a cowfish. That species forms groups of less than 10 in coastal waters, occasionally 25, and very rarely several hundred in offshore waters (Leatherwood et al. 1983). *Tursiops truncatus* is the most common species seen along the eastern coast of North America (Walker 1964; True 1903), with Cape Cod being in the northern part of its range (Watson 1981). Leatherwood et al. (1982) also note that this species sometimes has been referred to as common porpoise. The above article states that "They are not the common porpoises frequently seen . . ." which, along with the assumption that these names have not been used in the literature to describe this species, seems to exclude it as a candidate for cowfish.

Cowfish is listed by Walker (1964) to be any species of *Mesoplodon*. These beaked whales are not well known, and in a few cases, are only known from one or two stranded individuals (Leatherwood and Reeves 1983). Walker (1964) reported that the greatest number of individuals of a stranded *Mesoplodon* sp. was 25. Consequently, the likelihood of four separate strandings of more than 28 individuals in each case occurring in one week is extremely remote. Therefore, *Mesoplodon* is not a candidate.

The only other candidates are *Grampus griseus* and *Globicephala melas*. *Grampus*, now commonly known as Risso's Dolphin, was described as cowfish by Goode (1884). It is known to accompany *Globicephala melas* and has an average group size of 25 (Katona et al. 1983; Leatherwood and Reeves 1983; Watson 1981). Reports of them travelling in groups of several hundred have also been noted (Leatherwood and Reeves 1983; Katona et al. 1983). *Grampus* can attain the length of 14 feet (Leatherwood and Reeves 1983; Katona et al. 1983) which suggests that they could be the "larger variety" of the "common porpoise." However, Leatherwood and Reeves (1983) and Katona et al. (1983) note that these animals inhabit deepwater

TABLE 1. Reports of natural stranding of the Long-finned Pilot Whale, *Globicephala melas,* on Cape Cod for the period 1620 to 1990 with the date, location, and number of individuals stranded. Compiled from newspaper search, Smithsonian Institute, Washington, D.C., town records and history books.

Date	Location	Number
1620-Dec-06	Eastham, First Encounter Beach	003
1682- ?	Sandwich	?
1770- ?	Wellfleet	?
1793- ?	?	400
1809- ?	Provincetown	?
1820-21	Wellfleet	?
1832-Nov-2?	East Wareham	007
1843-Nov-06	Eastham	070
1846-Sep-2?	Barnstable Harbor	070
1846-Sep-25	Yarmouth, Central Wharf	044
1846-Sep-27	Yarmouth	028
1846-Oct-20	Eastham	100
1850 ?	Wellfleet to Truro	075
1853-Sep-03	North Wellfleet	082
1855-Jul-22	Truro	060
1856-Oct-1?	Truro	?
1861-Sep-04	Dennis Beach	100
1870-Nov-2?	Dennis Beach	003
1873-Jun-29	Orleans	160
1874-Sep-02	North Truro Station	028
1875-Dec-01	Provincetown	002
1912-Nov-25	East Brewster to Orleans	110
1912-Nov-?	Brewster	050
1913-Summer	Eastham	015
1913-Aug-31	Eastham	098
1913-Sep-09	Eastham	078
1914-Summer	Eastham	100
1914-Jul-07	South Wellfleet	175
1915-Sep-12	South Wellfleet, Blackfish Creek	110
1916-Oct-18	Eastham, Rock Harbor	500
1916-Oct-19	Eastham	100
1916-Oct-22	Truro, Pamet Harbor	057
1918-Jul-03	Nantucket	059
1918-Aug-2?	East Dennis	?
1918-Oct-27	Truro Beach	090
1925-Aug-02	East Brewster	068
1926-Aug-10	North Truro	500
1928-Jul-12	Eastham, Boat Meadow Creek	080
1928-Jul-12	Orleans, Bee's River	115
1929-Summer	Wellfleet	100
1929-Jul-05	Wellfleet, Mayo's Beach	020
1929-Aug-05	Eastham	010
1929-Oct-28	Brewster	068
1932-Aug-29	Wellfleet, Barber's Beach	030
1932-Sep-2?	Orleans, Namskaket Creek	020
1934-Aug-09	South Eastham	075
1934-Aug-18	Orleans, Rock Harbor	068
1934-Aug-26	South Eastham, Rock Harbor	030
1935-Aug-15	South Wellfleet	090
1935-Aug-19	South Wellfleet, Blackfish Creek	048
1935-Sep-20	Eastham	005
1936-Aug-07	Wellfleet Harbor	050
1937-Jul-?	South Wellfleet, Blackfish Creek	006
1937-Jul-14	Eastham, Herring Creek	097
1938-Jun-22	East Brewster	071
1940-Sep-08	Wellfleet	020
1941-Aug-09	Wellfleet	012
1942-Jul-18	Eastham	150+
1943-Aug-23	Eastham	200
1943-Oct-31	Brewster, Wings Island	100
1943-Nov-02	South Wellfleet, Blackfish Creek	020
1948-Jul-08	Wellfleet	027
1948-Aug-10	Eastham, First Encounter Beach	081
1949-Mar-02	Hyannis, Lewis Bay	011
1950-Jan-17	East Dennis	006
1950-Jan-20	Dennis	006
1952-Winter	Pocasset	003+
1954-Jan-?	Cape Cod	?
1954-May-22	Nantucket, Eel Point	002
1957 ?	Wellfleet	105
1958-Jul-05	South Wellfleet, Blackfish Creek	103
1958-Sep-?	South Wellfleet, Blackfish Creek	068
1963-Apr-?	Wellfleet, Lieutenant Island	046+
1965-Nov-22	Wellfleet, Great Island	002
1966-Nov-18	Eastham, First Encounter Beach	002
1968-Jul-?	Brewster	023
1979-Oct-09	Nauset Marsh	002
1981-Dec-06	Nantucket, Madeket Beach	018
1981-Dec-06	Nantucket	013
1982-Nov-16	South Wellfleet, Lieutenant Is.	066
1982-Dec-23	Eastham	024
1983-Dec-23	Wellfleet to Eastham	023
1984-Oct-06	Eastham	097
1984-Nov-21	Dennis to Truro	023
1986-Dec-03	Eastham	038
1986-Dec-19	Eastham	049
1990-Dec-11	Hyannis Port	055

Continued

TABLE 1. (Cont'd)

preferably greater than 100 fathoms. They also show marked preference for warm temperate to tropical waters (Leatherwood and Reeves 1983). Hoyt (1984), Katona et al. (1983) and Leatherwood and Reeves (1983) also added that *Grampus* is rare in Massachusetts but can be found north of Cape Cod during the summer months when the water warms. With this evidence, it is unlikely that over 600 individuals would strand in Cape Cod Bay in October, although the possibility is greater than with *Mesoplodon* sp. In addition, common names are rarely used to describe *Grampus*, and, these animals are grey rather than black in color.

Therefore, the species to which the article in the Yarmouth Register was referring is most probably *Globicephala melas*. This species has been given many common names; e.g., blackfish, pothead, ca'aing (i.e., howling) whale, long-finned pilot whale, pilot black whale, social whale, roundhead Heintzelman 1981; Watson 1981). The blackfish is known to frequent Cape Cod Bay from July to December and is known to strand in large numbers, upwards of 100 at a time, in areas such as Yarmouth,

Brewster, Barnstable Eastham, and Wellfleet (Table 1) (McFee 1990). *G. melas* attains lengths of 20 feet or more (Leatherwood and Reeves 1983). This places them in the "larger variety" of "common porpoises" with *Grampus*.

One week after the original article, on Thursday, 8 October 1846 the Yarmouth Register published the following statement: "A shoal of porpoises or blackfish ran themselves ashore near Cape Kildare, Prince Edward Island numbering 41 individuals." This would support the statement that porpoise and blackfish are used interchangeably as stated earlier. Still another article in the same paper on that day stated the following: "On Monday last at Barnstable Light house while out in the harbor . . . discovered a shoal of bass porpoises or cowfish, shot at the lead fish and wounded it. Drove 147 ashore." A blackfish herd has been mentioned to be led by a single individual (Walker 1964) which would support the above conclusion. This apparently confirms the use of another common name, bass porpoise.

The evidence presented above suggests that *Globicephala melas* is the most likely candidate for the species in the four strandings. However, the argument is confounded by the only other reference to cowfish which was published in 1915 in the Cape Cod Magazine (Anonymous 1915): "Great schools of blackfish and cowfish have frequented Cape Cod Bay recently." This suggests that two separate species were present. This last article appeared 70 years later than the original article. Perhaps the common name given to one species changed a couple of generations later. However, with the evidence presented above for *Globicephala melas* there is little doubt that this is the species being described.

The use of common names to describe small cetacean sightings should be carefully documented. Experts in the marine mammal field should be aware that laymen may apply any name to any small cetacean simply because they do not know the difference. Consequently, what may appear obvious to the layman may require further investigation by the expert.

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An Incident of Wolf, *Canis lupus*, Predation on a River Otter, *Lutra canadensis*, in Minnesota

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Route, William T., and Rolf O. Peterson. 1991. An incident of Wolf, *Canis lupus*, predation on a River Otter, *Lutra canadensis*, in Minnesota. Canadian Field Naturalist 105(4): 567–568.

Evidence was found of Gray Wolves (*Canis lupus*) killing and partially consuming a radio-marked River Otter (*Lutra canadensis*) in Voyageurs National Park, Minnesota. There is little evidence in the literature to suggest that Otters are a regular source of prey for Wolves, however, wolves may incidentally kill River Otter.

Key Words: Gray Wolf, *Canis lupus*, River Otter, *Lutra canadensis*, Wolf food habits, River Otter mortality, predation.

The North American River Otter (*Lutra canadensis*) has few natural enemies and is safe from most predators while in water. Larsen (1983) suggested that Killer Whales (*Orcinus orca*) consume an occasional Otter and Vallentine et al. (1972) found traces of Otter hair in the stomach of an American Alligator (*Alligator mississippiensis*). Otters are undoubtedly more vulnerable on land (Melquist and Donkert 1987): Bobcats (*Felis rufus*), Dogs (*C. familiaris*), Coyotes (*C. latrans*), and Red Foxes (*Vulpes vulpes*) are land carnivores documented as killing Otters (Seton 1926; Grinnell et al. 1937; Young 1958; Mowbrey et al. 1937). River Otter hair was found in three scats from Gray Wolves in north central Minnesota (Reimann 1983), but it is unknown whether wolves had scavenged or deliberately killed the Otter. This note documents the killing and partial consumption of an Otter by Gray Wolves.

During a study of River Otter distribution and abundance in Voyageurs National Park (VNP), Minnesota (48°30'N, 93°50'W) 42 Otters were live-captured and 25 were surgically implanted with temperature-sensitive radio transmitters (Route 1988). Average duration of radio contact was 246 days/Otter (range 7 – 433) for a total of 6150 Otter days.

On 5 May 1986, yearling female Otter F810 was captured, transmitted and released. This Otter was subsequently relocated 10 times and was located alive < 24 hours before being found dead on 2 September 1986. The carcass was found within her known home range in lowland forest 100 m from water. Fresh Wolf tracks and scats were found at the kill-site and a Wolf pack with pups was known to occupy a rendezvous site < 3 km away. The abdominal cavity of the Otter had been torn open and portions of the ribs and viscera were absent. The left forepaw, right hind leg, and tail had been chewed away. The radio transmitter was found among partially masticated viscera 1 m from the carcass. Tooth marks were present on the transmitter's wax coating.

The Otter was necropsied at the U.S. Fish and Wildlife Service's National Wildlife Health Laboratory (NWHL) in Madison, Wisconsin. It was determined that the Otter was in a good state of nutrition and the stomach and intestinal contents indicated it was actively feeding prior to death. There were no signs of infectious diseases or other debilitations. The long bones had been crushed, the lower mandibles were fractured, and traumatic lesions on the back and pelvis were "consistent with those expected to be produced by a large powerful predator such as a Wolf" (R. K. Stroud, DVM and P. A. Gullett, DVM, NWHL, personal communication). The final diagnosis was predator-related trauma.

This Wolf-killed Otter was one of three Otters determined to have died from natural mortality in our study (two other Otters were diagnosed by NWHL as dying from chronic cystitis [urinary infections], although stress from handling may have hastened death). Few radiotelemetry studies have been conducted on Otter where Wolves are present. Reid (1984) transmitted 26 Otter in north eastern Alberta and speculated that an unknown predator may have consumed one Otter. Although Wolf food habits studies show that Otter are of little importance to Wolves, where the two coexist, River Otter may be subjected to occasional wolf predation.

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First Specimens of the Rainbow Smelt, *Osmerus mordax*, from Lake Winnipeg, Manitoba

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Campbell, Kenneth B., Arthur J. Derksen, Richard A. Remnant, and Kenneth W. Stewart. 1991. First specimens of the Rainbow Smelt, *Osmerus mordax*, from Lake Winnipeg, Manitoba. Canadian Field-Naturalist 105(4): 568–570.

Two Rainbow Smelt, *Osmerus mordax*, were caught in commercial gillnets in the South Basin of Lake Winnipeg in September and October, 1990. Remains of a third specimen were identified in stomach contents of a Walleye, *Stizostedion vitreum vitreum*, caught in the South Basin in early June, 1990. Smelt may have reached Lake Winnipeg via one or more of three routes: downstream dispersal from the English River system; transport by man from the English River System to Berens Lake, in the watershed of the North Basin of Lake Winnipeg; and transport by man directly to the Red River/Lake Winnipeg System from the Great Lakes, Northwestern Ontario or Lake Sakakawea, North Dakota (Missouri River). The apparent absence of smelt from the Winnipeg River and Berens Lake, along with the South Basin location of the three specimens reported here, does not favour the first two possibilities. An anecdotal report, unsubstantiated by a specimen, raises the possibility that smelt may have been transported directly to the Red River Lake Winnipeg System as early as 1975.

Key Words: Rainbow Smelt, Lake Winnipeg, Manitoba, Hudson Bay Drainage, exotic fish, introduction, zoogeography.

On 26 September, 1990, Mr. Mike Martin, a commercial fisherman operating on Lake Winnipeg, out of Arnes Harbour, Manitoba, caught a Rainbow Smelt, *Osmerus mordax*, in a 8.26 cm mesh (stretched measure) gillnet, set overnight, fishing a depth range of 1 to 6 m, in 11.3 m water depth, about 5.6 km due east of Arnes Harbour, at 50° 48'N, 96° 52'W (specimen 1). A second smelt (specimen 2) was caught between 1 and 6 October 1990 by Mr. Glen Halgren, also a commercial fisherman, operating out of Victoria Beach, Manitoba. This specimen was caught about 5.6 km west of the Government Dock at Victoria Beach, at 50° 42'N, 96° 40'W, or about 22 km south-southeast of specimen 1, in an overnight set using the same type of gear as Mr. Martin, but fishing in water 9 m deep, in a depth range of 1 to 9 m. Both fish had their teeth entangled in threads or knots in the mesh and were found dead in the nets. The fishermen brought their catches to two of us (Campbell and Derksen, respectively) for identification.

A third specimen was identified by one of us (Remnant) among the stomach contents of a Walleye (*Stizostedion vitreum vitreum*) caught in the south basin of Lake Winnipeg and landed in the commercial catch at Riverton, Manitoba, on 4 June 1990. This sample was the only one of 952 adult Walleye stomachs (510 with identifiable contents) which contained smelt remains. The stomachs were collected from commercial fish landings at points around both

the south and north basins of the lake during May and June, 1990.

Specimen 3 consists of the posterior 32 vertebrae; including the caudal skeleton, 20 vertebrae with closed hemal arches and 12 precaudal vertebrae. It was identified by comparison with identified reference skeletal material of Goldeye, *Hiodon alosoides*, Lake Cisco, *Coregonus artedii*, Northern Pike, *Esox lucius*, Rainbow Smelt, *Osmerus mordax*, Emerald Shiner, *Notropis atherinoides*, White Sucker, *Catostomus commersoni*, Black Bullhead, *Ictalurus melas*, Troutperch, *Percopsis omiscomaycus* and Yellow Perch, *Perca flavescens*. All of these species are found in Lake Winnipeg and may be eaten by Walleye. The stomach which contained the smelt also contained partial vertebral columns with caudal skeletons of two Emerald Shiners and an articulated series of Lake Cisco caudal vertebrae which lacked the caudal skeleton.

Stewart verified all identifications and determined that specimens 1 and 2 agreed with the description of *O. mordax* given by Scott and Crossman 1979. Specimens 1 and 2 have been placed in the Royal Ontario Museum (Catalogue Numbers 60429 and 60430, respectively), and specimen 3 is in the fish collection at the University of Manitoba Department of Zoology. After fixation in 10% formalin for two days, specimens 1 and 2 had standard lengths of 117.6 mm and 124.0 mm respectively. Both specimens are immature, and have large deposits of mesenteric fat. Specimen 1 is a female, and specimen 2 a male. The scales of both specimens show one poorly defined annulus, and no marginal annulus, as would be expected for fish at the end of their second summer, because smelt begin annulus formation in June (Becker 1983). The size and age of these specimens would be consistent with maturation in spring, 1991 or 1992 (Scott and Crossman 1979; Becker 1983).

The earliest known occurrence of Rainbow Smelt in the Hudson Bay Drainage was in Little Eagle Lake, 49°54'N, 94°13'W, Ontario, in 1962 (C. Hansson, unpublished Ontario Ministry of Natural Resources Report, undated). Little Eagle Lake was poisoned at Manitoba's request in 1978. It has no surface inlet or outlet, which would preclude emigration by smelt as a means of dispersal, but the possibility of transport by man during the 16 years that smelt were present cannot be eliminated.

Smelt were discovered next in two Rainy River headwater lakes in 1972: Eva Lake, Ontario, 48° 43'N, 91° 10'W (Crossman 1976), and Burntside Lake, Minnesota, 47° 54'N, 91° 58'W, Minnesota (Geis, personal communication 1991).

In 1987, one of us (Derksen) was part of a group of Ontario and Manitoba provincial fishery biologists which confirmed Rainbow Smelt spawning runs in two inlet streams of Red Lake, Ontario, 51° 01'N, 93° 50'W, as well as in its outlet, the Chukuni River (English River System).

Barton et al. (1990) have either verified the occurrence of, or first found smelt in a total of six lakes in the English River System, three in the Wabigoon River System, and eight lakes in the Rainy River System. The closest location to Lake Winnipeg in which smelt have been found is Separation Lake, 50° 15'N, 94° 27'W, on the lower English River, 240 km by river upstream from Lake Winnipeg (Lockhart, personal communication 1991).

So far, smelt have not been found in the Winnipeg River, Lake of the Woods or the Rainy River below Rainy Lake (Franzin, personal communication 1990). Surveys by the Minnesota Department of Natural Resources of headwater lakes of the Red River System in Minnesota also have not found smelt (Drewes, personal communication 1991).

Smelt could have reached Lake Winnipeg by one or more of the following routes. (1) They could have moved downstream via the Winnipeg River from the English River. (2) They could have been transported by man from the English River System to the Lake Winnipeg Watershed in Northwestern Ontario. Red Lake, in the English River System, has smelt and is located about 100 km by road south of Berens Lake, 51° 47'N, 93° 45'W, which is a headwater of the Berens River, a tributary of the North Basin of Lake Winnipeg. (3) They could have been transported by man directly into the Red River Watershed or Lake Winnipeg from Northwestern Ontario, the Great Lakes or Lake Sakakawea, North Dakota, on the Missouri River.

The failure, up to now, to find smelt in the Winnipeg River, or anywhere downstream of Separation Lake, suggests that the Lake Winnipeg occurrence is not the result of downstream movement of smelt in the Winnipeg River (possibility 1). Collections made in Berens Lake during the summer of 1990 did not yield smelt (Franzin, personal communication 1990). This, combined with the fact that all three smelt found so far in Lake Winnipeg were from the south basin, is evidence against possibility (2). Although the recent surveys of Red River headwater lakes in Minnesota have not found smelt, there is an anecdotal report of a smelt from the Red River in Canada in 1975. Mr. Peter Vanriel (personal communication 1990) asserted that he had angled a rainbow smelt, approximately 25 cm long, from the Red River, immediately below the St. Andrews Dam in "May or June, 1975." He had discussed this recollection with one of us (Stewart) on several occasions since 1986. The timing of this occurrence would favour possibility (3), a direct transfer of smelt to the Red River or Lake Winnipeg.

The combination of negative evidence and an anecdotal report unsubstantiated by a specimen does not conclusively favour or reject any of the above possible routes for transfer of smelt to Lake Winnipeg. Indeed, all may have occurred or may still be in progress. It is notable that smelt may have been at large in the Red River/Lake Winnipeg System as

long ago as 1975. There may have been failed introductions in the past, of which the 1975 Red River occurrence is an example. If smelt have been present in Lake Winnipeg since about 1975, they may be well established and on the verge of undergoing a large increase in abundance. On the other hand, if the present occurrences are the result of a more recent introduction or downstream dispersal, smelt might be expected to remain uncommon for a longer time.

The occurrence of only one smelt in the series of 952 Walleye stomaches from Lake Winnipeg is evidence that smelt may not have reached high levels of abundance in Lake Winnipeg so far. Since all three smelt found so far were from the South Basin of Lake Winnipeg, colonization of the North Basin by smelt may be at an even earlier stage.

Smelt appeared in Lake Winnipeg sooner than any of us had anticipated, based on their distribution in Northwestern Ontario and our conjecture about their rate of downstream dispersal in the Winnipeg River. This also favours transport by man rather than dispersal as the means by which smelt reached Lake Winnipeg. The increasing use by anglers of boats equipped with aerated livewells makes the uncontrolled transport of large numbers of live fish over long distances possible. This, combined with the practice of dumping unused live bait into the water, may become the most important single source of unauthorized introductions of exotic fish both in Canada and the United States.

Acknowledgments

We wish to thank the following people who made their unpublished information on smelt distribution in the Hudson Bay Drainage available to us: Henry Drewes, Minnesota Department of Natural Resources, Fisheries Section, 2115 Birchmont Beach Road N.E., Bemidji, Minnesota, 56601; W. Franzin, Canada Department of Fisheries and Oceans, Freshwater Institute, University of Manitoba, Winnipeg, Manitoba, R3T 2N2; Joe Geis, Minnesota Department of Natural Resources, Fisheries Section, 1429 Grant McMahan Boulevard, Ely, Minnesota, 55731; Scott Lockhart, Ontario Ministry of Natural Resources, Fisheries Branch, P.O. Box 5080-808 Robertson Street, Kenora, Ontario, P9N 3X9; and Peter Vanriel, Terrestrial and Aquatic Environmental Managers, Ltd. #6-301, 45th Street West, Saskatoon, Saskatchewan, S7L 5Z9.

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Addenda

Franzin (personal communication 1991) has now confirmed Rainbow Smelt in Lake of the Woods, Ontario. Also, during the summer of 1991, additional smelt have been collected in Lake Winnipeg, including two from the North Basin. One was landed by a commercial fisherman at Pine Dock, 51°38′N, 96°50′W. The other, also landed by a commercial fisherman was taken at Eagle Island, 53°39′N, 98°53′W. These two captures confirm the presence of smelt at both the southern and northern extremities of the North Basin of Lake Winnipeg.

KENNETH W. STEWART

Received 29 January 1992

Eubranchipus intricatus Hartland-Rowe, 1967: First Confirmed Record of a Fairy Shrimp (Crustacea: Anostraca) from Nova Scotia

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Daborn, Graham R., James Wolford, and Pierre Taschereau. 1991. *Eubranchipus intricatus* Hartland-Rowe, 1967: first confirmed record of a fairy shrimp (Crustacea: Anostraca) from Nova Scotia. Canadian Field-Naturalist 105(4): 571–572.

The fairy shrimp, *Eubranchipus intricatus* Hartland-Rowe, 1967, is recorded from a semi-permanent pond in Blomidon Provincial Park, Nova Scotia (45°16'N, 64°20'W), from which it has been collected for the past three years. This is apparently the first authenticated record of the Anostraca from the Maritime Provinces and Newfoundland.

Key Words: *Eubranchipus intricatus*, fairy shrimp, Anostraca, new record, Nova Scotia.

The fairy shrimps are widely distributed crustaceans, typically inhabiting temporary or semi-permanent ponds around the world. Most live in water of low conductivity, although a few, especially the brine shrimps of the genera *Artemia* and *Parartemia*, and some species of *Branchinecta* and *Branchinella*, occur in saline lakes in arid areas, or in coastal lagoons (Dexter 1959; Hartland-Rowe 1965). In Canada, the order Anostraca is represented by at least 16 species (Belk 1975), some of which are found in most provinces and the territories. We record here the occurrence of *Eubranchipus intricatus* Hartland-Rowe, 1967 (family Chirocephalidae), from a locality in Nova Scotia which it has inhabited for at least three years. This constitutes the first authenticated record of the group from the province, leaving only New Brunswick, insular Newfoundland and Prince Edward Island without formal records of an anostracan.

Collection Records

Fairy shrimp were first noted in a semi-permanent pool in Blomidon Provincial Park, Nova Scotia (45°16'N, 64°20'W), by P. Taschereau on 14 May 1988. A collection of 6 males and 6 females was made by G. Daborn and J. Wolford on 17 May 1988. All individuals were mature or nearly so, measuring 9-12 mm in length. None of the females carried eggs in the egg sac. The pond was visited again by G. Daborn on 18 May 1989, and the presence of mature fairy shrimp confirmed, although no specimens were collected. On 28 May 1990 G. Daborn, E. Bishop, and K. Kuftu made a second collection, which included 21 mature males and 24 females. Specimens from this collection were used for identification purposes, and have been deposited in the Canadian Museum of Nature (Catalogue Number NMC 1990-0178) and the Nova Scotia Museum (Accession number 990-100).

Notes on *Eubranchipus intricatus*

This species is closely similar to the widespread and commonly recorded *Eubranchipus bundyi*, with which it may co-occur (Hartland-Rowe 1967), and has a similar life cycle (Daborn 1976). Perhaps because of taxonomic confusion (cf Brtek 1966), records exist only for Alberta, Saskatchewan and Manitoba in Canada, and for Massachusetts in the United States (Brtek 1966; Belk 1975). Most of these records were re-evaluations of museum specimens by Hartland-Rowe. *E. intricatus* can be readily distinguished from *E. bundyi* by reference to the description and diagrams in Hartland-Rowe (1967). In one respect, however, our 1990 specimens differ from the description provided by Hartland-Rowe in that the antero-dorsal swellings on the female egg sac are much more prominent than shown in Hartland-Rowe's Figure 3. In our mature females, these swellings are distinct, rounded prominences with heavy sclerotization that cannot be concealed beneath the lateral processes of the 11th thoracic segment (Figure 1A). Examination of the 1988 collection showed that in all six females the anterodorsal swellings were much less conspicuous, and matched Hartland-Rowe's drawing very well. It is probable that his specimens, like ours from 1988, were not fully mature, and that the swellings become more pronounced and heavily sclerotized with age. Males conform quite well to the original description, with the minor exception that the terminal end of the distal segment of the second antenna (clasper) is more hand-shaped than suggested in Hartland-Rowe's account (Figure 1 C, D). His figure is a lateral view that does not capture either the curved form of the distal article or the expanded end (cf Figure 1 E).

This finding constitutes the first confirmed record of a fairy shrimp in Nova Scotia. Most reference works (e.g., Dexter 1959; Belk 1975) include a Nova Scotian record for the arctic fairy shrimp

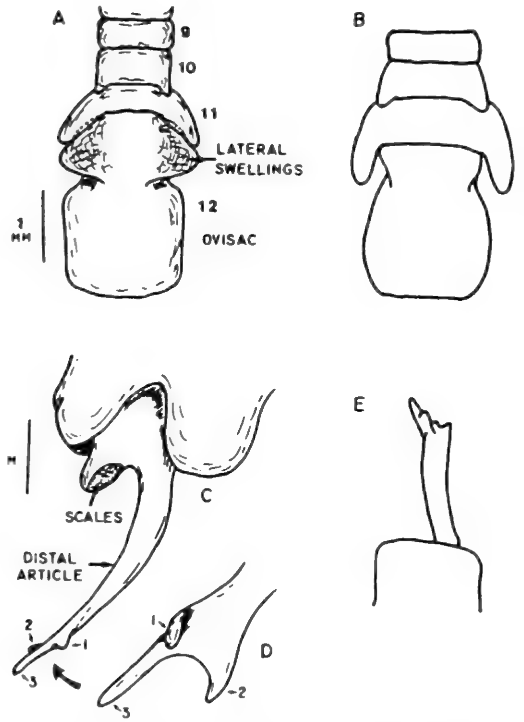

FIGURE 1. *Eubranchipus intricatus* Hartland-Rowe, 1967.
A. Dorsal view, thoracic segments 9-12 from mature 11.0 mm female.
B. Hartland-Rowe's original figure 3.
C. Ventral view, left second antenna (clasper) from 12.1 mm male. 1-3, terminal processes of distal article (Arrow shows orientation of D).
D. Postero-ventral view of processes 1-3, showing broad hand-like end of distal article in mature male.
E. Hartland-Rowe's original figure 1. Note that this is a lateral view, which does not show the curvature of the article.
A, C and D from specimens collected at Blomidon Provincial Park, Nova Scotia, 28 May 1990.
B and E from Hartland-Rowe (1967).

Branchinecta paludosa (Muller 1788), following Dexter (1953). That record was based upon a collection received on 10 December 1928 by the American Museum of Natural History. The locality was given as "Taylor Harbor, Nova Scotia", which Dexter (1953) concluded might have been "Taylor Head". No other information was provided, nor has the species been recorded again in Nova Scotia in spite of a search of the Taylor Head area in 1975 (Daborn, unpublished information). *Branchinecta paludosa* is an arctic and subarctic species which extends southward into west and central Canada, and into the United States along the Rocky Mountains (Linder 1941; Hartland-Rowe 1965; Belk 1975; Maynard 1976). Its southward distribution seems to be associated with major flyways for migratory waterfowl (Daborn 1978).

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A Leucistic Eastern Redback Salamander, *Plethodon cinereus*, and an Albinistic Yellow-spotted Salamander, *Ambystoma maculatum*, from Southern Ontario

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Rye, Leslie A. 1991. A leucistic Eastern Redback Salamander, *Plethodon cinereus*, and an albinistic Yellow-spotted Salamander, *Ambystoma maculatum*, from southern Ontario. Canadian Field-Naturalist 105(4): 573–574.

A leucistic Redback Salamander, *Plethodon cinereus*, was found near Brant Hills (43°30'20"N, 79°51'32"W) and an albinistic Yellow-spotted Salamander, *Ambystoma maculatum*, was found near Mount Healy (43°00'02"N, 79°54'15"W) in the Ontario Regional Municipalities of Halton and Haldimand-Norfolk respectively. This is the first report of a leucistic *P. cinereus* in Canada and of an albinistic *A. maculatum* in Ontario.

Key Words: Albinistic, leucistic, Redback Salamander, *Plethodon cinereus*, Yellow-spotted Salamander, *Ambystoma maculatum*, Ontario.

During the summer of 1989, two abnormally pigmented salamanders, an Eastern Redback Salamander (*Plethodon cinereus*) and a Yellow-spotted Salamander (*Ambystoma maculatum*) were found during an intensive herpetofaunal survey of the Hamilton area in southern Ontario. Both specimens were delivered to the University of Guelph, Guelph, Ontario where colour photographs are on file. The salamanders have been deposited in the Canadian Museum of Nature (NMC) in Ottawa and are described here.

On 16 May 1989 an adult male *Plethodon cinereus* (NMC 33081) was collected along the Niagara Escarpment approximately 1 km NW of Brant Hills (43°30'20"N, 79°51'32"W) in the Ontario Regional Municipality of Halton. The salamander was kept alive in the University of Guelph collection but on 16 August 1990 was found close to death and was killed by prolonged anesthesia in MS222. The body of this specimen lacked all pigment and appeared white but the eyes were normally coloured and therefore the specimen was, using the terminology of Dyrkacz (1981), considered a leucistic individual.

Two albino *Plethodon cinereus* have been reported from Maryland, one from Maine (Hensley 1959, Dyrkacz 1981), and two partial albinos were found in Nova Scotia (Gilhen 1986). A leucistic specimen was found in New York (Hensley 1959), but the present note appears to be the first report of a leucistic *P. cinereus* in Canada.

On 3 August 1989 a female *Ambystoma maculatum* (NMC 32831) with a snout – vent length of 88.2 mm was collected approximately 1.5 km W of Mount Healy (43°00'02"N, 79°54'15"W) in the Ontario Regional Municipality of Haldimand-Norfolk. The specimen was maintained alive until 2 May 1990 when it was killed in MS222 and tissues were taken for future electrophoretic analysis. The body of this salamander was pinkish-white in background colour with distinct groupings of xanthophores typical of *A. maculatum*. A few scattered melanophores were visible on the tail. The eyes of the living specimen appeared dark, not red, even when viewed parallel to a light beam. This differed from the eyes of the specimens reported by Lowcock (1985) and Smith and Michener (1962). The presence of both normally coloured eyes and xanthophores preclude the use of any terminology proposed by Dyrkacz (1981) to describe this specimen. However, since this salamander obviously possessed some degree of albinism, it will be referred to as albinistic.

This is the first report of an albinistic *A. maculatum* from Ontario, although a total of seven albinistic specimens have been reported from Quebec (Lowcock 1985), Kentucky, Tennessee, Maryland and New York (Hensley 1959, Dyrkacz 1981). None of these previously reported specimens is described as having xanthophores.

Albinistic amphibians appear to be rare in Ontario (as elsewhere). Previously reported species with albinistic individuals found in Ontario include the Bullfrog (*Rana catesbeiana*), the Mudpuppy (*Necturus maculosus*) and the Chorus Frog (*Pseudacris triseriata*) [Hensley 1959, Dyrkacz 1981]. This finding of two albinistic salamanders within a relatively small geographic area suggests that perhaps albinism may be more frequent than previous reports indicate and that other intensive herpetofaunal surveys may reveal further incidences of this condition.

Acknowledgments

I thank Bill Lamond, whose work is contributing greatly to the knowledge of Hamilton area herpetofauna, for bringing these specimens to my attention.

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A Wolf Spider, *Hogna helluo*, feeding on a Blue-spotted Salamander, *Ambystoma laterale*

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McLister, James D., and William Lamond. 1991. A wolf spider, *Hogna helluo* (Lycosidae), feeding on a Blue-spotted Salamander, *Ambystoma laterale*. Canadian Field-Naturalist 105(4): 574–575.

A female wolf spider (*Hogna helluo*) was observed feeding on a juvenile Blue-Spotted Salamander (*Ambystoma laterale*) near Cambridge, Ontario.

Key Words: Wolf spider, *Hogna helluo*, Araneae, Lycosidae, Blue-spotted Salamander, *Ambystoma laterale*, Caudata, Ambystomatidae, predation, Ontario.

Many instances of spider predation on amphibians have been documented, always involving anurans or larval amphibians (McCormick and Polis 1982). Spiders are thought to be important predators of small, postmetamorphic individuals of some frog species (Formanowicz et al. 1981; Hayes 1983) but to the best of our knowledge, this is the first report of spider predation on a postmetamorphic salamander.

On 15 August, 1990, in a woodlot (43°19'N, 80°07'W) 16.5 km ESE of Cambridge, Ontario, one of us (WL) found a wolf spider (family Lycosidae) feeding on a juvenile Blue-spotted Salamander, *Ambystoma laterale* Hallowell, underneath a log. Although much of the anterior end of the salamander had presumably been eaten, including the head and forelimbs, the tail was still twitching. Both the spider and the salamander were collected and frozen.

In the lab, species identification of the salamander was verified by the electrophoretic analysis of a tissue sample in the manner described by Bogart (1982). The salamander was later preserved in 10% buffered formalin and the spider was preserved in 70% ethanol. The remnants of the salamander suggest that it was approximately 50 mm in total length. No gonadal tissue could be located in the specimen, but the time of year, the size of the salamander remains, and the presence of several other juvenile salamanders in the area suggest that it was a juvenile. The spider, which was identified as an adult female *Hogna helluo* (Walckenaer), had a body length of 17 mm.

Because the spider was not observed attacking the salamander, it is not known whether predation actually occurred or whether the spider scavenged the salamander remains from another predator. Lycosids will accept dead prey items under laboratory conditions and it has been suggested that scavenging may contribute to their natural diet (Nentwig 1987). However, lycosids generally hunt by remaining motionless and attacking prey items that wander within reach, not by foraging (Edgar 1969; Nentwig 1986); because the salamander's tail was still twitching, it is reasonable to assume that it was alive when the spider grabbed it and that this was a case of predation.

Studies of interactions between spiders and frogs indicate that spiders will pounce upon, but immediately reject, certain toxin-producing species (Szelistowski 1985; Cocroft and Hambler 1989). According to Brodie (1977), *Ambystoma laterale* has a high concentration of toxin-producing glands on its tail and, when threatened by potential predators, will stick its tail straight up and wave it back and forth. If the salamander is grasped, "the tail, secreting heavily, is lashed forward and rubbed back and forth on the grasping object" (Brodie 1977). In the confining space beneath a log, it is unlikely that *A. laterale*

would be able to assume this antipredator posture and so the anterior end of the salamander may have been more vulnerable to the spider's attack. Although a single observation is only suggestive, perhaps sympatric salamander species having higher concentrations of toxin-producing glands about the head region as well as the tail are less susceptible than *A. laterale* to predation when underneath logs and stones.

Acknowledgments

We wish to thank J. Redner of the Biosystematic Research Institute and R. Bennett for their assistance in identifying the spider. We also thank L. Rye and W. Cook for their contributions in the lab.

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The Effect of Temperature on the Relative Abundance of Flies of the *Drosophila affinis* (Sub-group) Collected Near Ottawa, Ontario

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Beninger, Clifford W. 1991. The effect of temperature on the relative abundance of flies of the *Drosophila affinis* (subgroup) collected near Ottawa, Ontario. Canadian Field-Naturalist 105(4): 575–578.

The relative abundance of the three species in the *Drosophila affinis* subgroup was not significantly correlated with changes in summer high temperatures in 1986. However, the two most abundant species in collections were the cold-adapted *D. athabasca* and *D. algonquin* respectively, which have at least one generation per year in the Ottawa area. Their predominance may be the result of below normal temperatures that occurred during the summer. The male bias in baited collections may result from the greater attraction of females to natural oviposition sites, rather than the bait.

Key Words: *Drosophila*, temperature, abundance, phenology, Canada.

Studies of the seasonality of insect populations are important in understanding their population dynamics and their responses to environmental conditions, particularily to temperature. Such studies provide data that may be applicable to future analysis of short and possible long-term climate change in North America.

Of the estimated 2000 species of flies of the genus *Drosophila,* 200 occur in North America alone. The *Drosophila affinis* sub-group includes three closely related species: *Drosophila affinis, D. athabasca* and *D. algonquin*. These form part of the *D. obscura* group of the sub-genus *Sophophora*, family Drosophilidae (Wheeler 1981). The distribution patterns of the *D. affinis* sub-group species have been linked to temperature-correlated differences in relative fitness (Miller 1958; Collier 1978; Fogleman 1979). Hey and Houle (1985, 1987) have reared *D. athabasca* in the laboratory and studied habitat choice by *Drosophila affinis* males. However, little is known of the phenology and population dynamics of this subgroup.

As part of a larger study of their reproductive biology and diapause (Beninger 1988, 1989), the abundance of each of the three subgroup species was compared to their total abundance and then correlat-

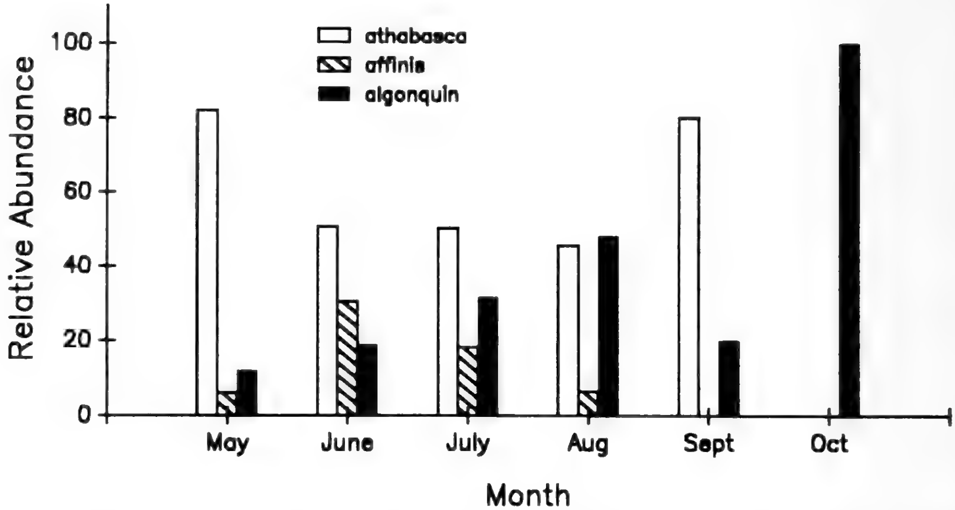

FIGURE 1. Relative abundance of *Drosophila affinis* subgroup species collected near the city of Ottawa. Athabasca = *Drosophila athabasca*, affinis = *D. affinis*, algonquin = *D. algonquin*.

ed with temperature records for the summer of 1986. Although limited, these data are of interest because of the lack of information on these species. As the data were collected during a year of abnormally low summer temperatures, they may indicate how these three populations respond during a period of climatic stress.

Methods

Adults were collected at fermenting banana baits (Spencer 1950) near the Mer Bleue bog (45°24'N; 75°32'W; 80 m above sea level) approximately 3.0 km to the east of Ottawa city limits in the Ottawa-Carleton Regional Municipality, Ontario. Vegetation at the collection site was a stand of young poplar (*Populus balsamifera*) and Red Maple (*Acer rubrum*) with a thick layer of undergrowth. Six plastic cups were separated by 5.0 m and hung in tree branches at a height of approximately 1.5 m above the ground. Bait was replaced every four days, or earlier if washed out by rain. Collected adults were transported back to the laboratory where they were anaesthetized with carbon dioxide gas, identified to species, and scored as "teneral" (1–3 days after emergence from the puparium) or "non-teneral" (> 3 days after emergence). The cuticle of teneral flies was typically soft and un-pigmented relative to non-teneral adults. Females of the *D. affinis* sub-group appear identical morphologically, but males may be assigned to species by differences in the sex combs of the forelegs. Summer collections were taken twice daily (weather permitting), in late morning and early evening. In September and October collections were taken in the early afternoon. Temperatures used were those recorded by staff at the Ottawa International Airport (45°20'N; 75°41'W; altitude 100 m above sea level). Arcsine transformed species frequencies and the mean of high temperatures taken daily for 11 two-week periods were used in the correlation analysis following the procedure of Collier (1978). An arcsine transformation is used to convert proportional, or frequency data for further statistical analysis because the variance is proportional to the mean, and the transformed data more closely approximate a normal distribution (Ostle and Malone 1988). Collection data for September and October were not used in this analysis due to small sample sizes.

Results

Figure 1 is a monthly summary of the relative frequency of flies caught during the study period. *Drosophila athabasca* was the most abundant species caught throughout the study period, while *D. algonquin* increased gradually in abundance from May through August. *Drosophila affinis* reached its greatest abundance in June, but never surpassed *D. athabasca*, and was generally less abundant than *D. algonquin*. Teneral males of both *D. algonquin* and *D. athabasca* were found in July (Table 1), but no tenerals of *D. affinis* were observed. In October, *D. algonquin* was the only species caught, but sample sizes were very small (only two male flies were trapped in that month). During the summer months, the number of non-teneral males caught at traps outnumbered the females by more than 2:1 (Figure 2).

There was no significant correlation with temperature for *D. affinis* ($r = -0.04$, $p = 0.915$) or *D. athabasca* ($r = -0.40$, $p = 0.283$) or *D. algonquin* ($r =$

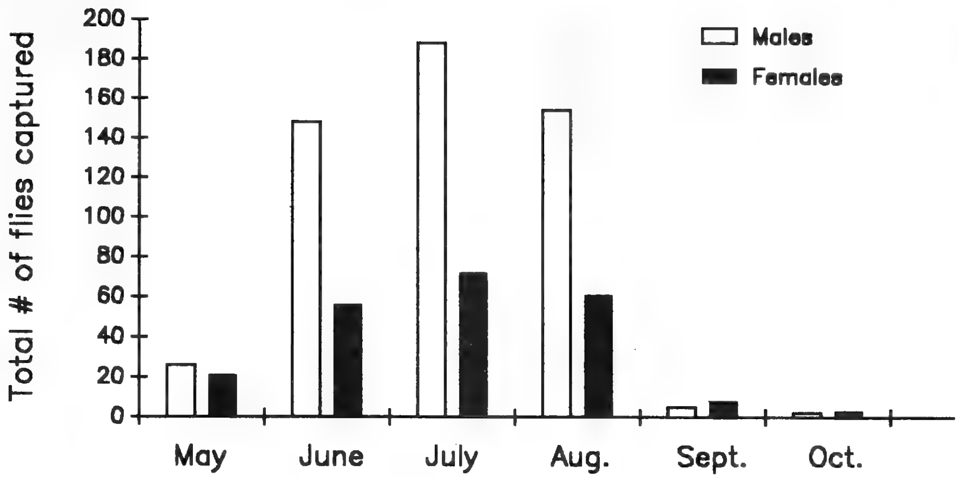

FIGURE 2. Sex ratio of collected flies (non-teneral), males of all species combined.

0.61, p = 0.078) over total range of mean summer high temperatures of 23.5 to 28.5°C.

Discussion

The presence of teneral *D. algonquin* and *D. affinis* females in the summer, and the short generation time for these species in the laboratory (10–14 days, personal observation), indicates that they have at least one, and possibly several generations per year in the Ottawa area. Another member of the *D. obscura* group, *D. obscura,* has 3 to 4 generations per year in England (Begon 1976; Begon and Shorrocks 1978). There is no information available on the phenology of other North American species.

The lack of significant positive correlation between high temperatures and abundance of *D. affinis*, and similar lack of a significant negative correlation between high temperatures and abundance of *D. algonquin* and *D. athabasca* was surprising with respect to Collier's (1978) findings. As temperatures were recorded 8.0 km away from the collection site, and at a slightly higher elevation, it is possible that they differed significantly from those at the field site. However, the narrow range of mean high temperatures during the unusually wet and cool summer of 1986 may be an equally plausible explanation for the lack of significant correlations. Lack of competitive fitness at lower temperatures may explain why *D. affinis* was the least abundant species caught and may have contributed to an increase in the relative abundance of *D. algonquin* and *D. athabasca*, which are more competitive at lower temperatures (Fogleman 1979). High rainfall that accompanied below normal temperatures may also have had an effect on relative abundances.

Miller (1958) found that males were most abundant when collections were taken during extremely hot days, perhaps indicating that females do not fly at high temperatures. This explanation is unlikely given the cool summer temperatures in my study. However, type of bait used is known to affect the frequency and sex of species of *Drosophila* which are attracted (Carson and Heed 1983; Dorsey and Carson 1956). The male bias in collections may therefore be the result of greater female attraction to natural oviposition sites, than to the bait.

TABLE 1. Collection dates and number of teneral males and females collected.

Collection Period	Females all species	Males *athabasca*	*affinis*	*algonquin*
30–31 May	1	0	0	0
3–26 June	0	0	0	0
28–30 June	5	0	0	0
1–2 July	3	2	0	2
14–18 July	9	1	0	1
21–23 July	4	0	0	0
3–17 August	0	0	0	0
19–21 August	5	0	0	0

Acknowledgments

I thank G. R. Carmody for his support and initial review of the manuscript, and S. M. Smith for a constructive and critical review.

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News and Comment

The Ottawa Field-Naturalists' Club 1990 Awards

At the Club Soirée on 26 April 1991, three of our four awards were presented for 1990 activities and achievements. President Roy John described the four awards that were set up in 1981, read the citations and presented certificates to the three winners, all of whom were present. Roy regretted that, for the fourth time in its history, no fitting candidate for the Anne Hanes Natural History Award had been identified.

As usual, a number of members of The Macoun Field Club (the junior naturalists group jointly sponsored by the Canadian Museum of Nature and the OFNC) attended the Soirée, and presented an attractive array of exhibits based on their interests. Rebecca Danard, Melanie Lussier and Shelby Banner won prizes for their exhibits. Also, the presidents of the Juniors, Intermediates and Seniors summarized the year's activities in their Divisions.

Member of the Year Award: Francis R. Cook

Francis Cook, Curator of Herpetology in the Canadian Museum of Nature, is Editor of *The Canadian Field-Naturalist*. This journal, our official publication, is recognized as a unique publication by both contributors and readers.

Francis's ties to the journal are impressive: he was Editor from 1962 to 1966; Associate Editor (herpetology) from 1973 to 1981; and he returned as Editor in late 1981 following development of our Club's Publication Policy, in which he was also involved. He has done much to maintain the status of this journal as an important and visible part of our Club. His efforts to bring it back on schedule are thus very valuable to us; last year saw six issues appear, and recovery of the regular schedule is in sight.

Francis Cook's support of our Club has not been limited to editorship, but it is for his recent work towards schedule recovery that we have real pleasure in presenting him with the Member of the Year Award for 1990.

Service Award: Robert E. Lee

Rob Lee has been an important part of the leadership of the Macoun Field Club since 1984. During many of those years he led indoor meetings, and has always been and continues to be a valuable field trip leader. As such, he has given generously of his time, and accepted responsibilities for the smooth operation of many club activities. He has encouraged members to develop their own skills of observation, and to undertake independent studies, especially of the plants and animals of the Macoun Field Club study area. Most importantly, Rob is a keen and inquiring observer of nature, and it is that spirit that he has been able to impart to the young members of the Macoun Field Club.

It is with special pleasure that we recognize Rob with the 1990 Service Award.

Conservation Award: Phil Reilly

This year's recipient of our Conservation Award, Phil Reilly, has spent the better part of his lifetime pursuing the goal of increasing environmental awareness in the Ottawa area. While still at university, he became one of the founding members of Pollution Probe — Ottawa. He has spent the subsequent years as an environmental consultant working for a number of federal departments and private organizations.

In recent years, Phil has taken a strong lead in several of the more controversial environmental issues in the region. As Chairman of the Wetlands Preservation Group of West Carleton, he led the efforts to block the development of a Class 1 Wetland on Constance Creek. Last year, Phil became a founding member and a member of the Board of Directors of ECOVISION, an area coalition of environmental groups and individuals aimed at improving the effectiveness of environmental programs. In this position, and as a member of the Club's Conservation Committee, Phil has played a leading role in the battle to save the Leitrim Wetland, another Class 1 wetland in the region.

For his consistent environmental stand, the Club recognizes the dedication of Phil Reilly with its 1990 Conservation Award.

President's Prize: Peter W. Hall

Jeff Harrison, immediate Past-President, presented the 1990 President's Prize to Peter Hall, who has been deeply involved in bringing the OFNC's Wildlife Garden project into being. The arrangement with the Central Experimental Farm, The Friends of the Farm, and the OFNC is on a firm basis. The selected area, south of the Arboretum, has undergonesome wildlife and plant surveys, and plans are underway to modify the existing drainage pattern to improve certain habitats. Long range plans are being developed and Peter has identified volunteers and keeps them informed of discussions and progress.

BILL GUMMER
Chairman, Awards Committee

Books on John Macoun Available

Members of The Ottawa Field-Naturalists Club and subscribers to *The Canadian Field-Naturalist* should note that The University of Toronto Press is offering *The Field-Naturalist: John Macoun, the Geological Survey, and Natural Science* by W. A. Waiser (0-8020-2686-9), published in 1989, discounted at $24.00 (formerly $30.00) plus postage and handling $2.50 for one and $0.75 for each additional copy. (Outside Canada prices are in U.S. dollars, and New York residents should add 8% sales tax). Cheques should be made payable to the University of Toronto Press; VISA and MasterCard are also accepted; institutional orders should attach order forms). Orders should be addressed to Manager, Direct Mail Marketing, University of Toronto Press, 10 Mary Street, Suite 700, Toronto, Ontario, M4Y 2W8. This book was reviewed in *The Canadian Field-Naturalist* 104(2): 336-337 (1990) by Marianne Gosztonyi Ainley.

Macoun's own, somewhat different, view of his contributions written within the perspective of his own time, *Autobiography of John Macoun*, is still available as a revision of the 1922 original as Special Publication Number 1 of The Ottawa Field-Naturalists' Club (1979) for $12.50 per copy plus $2.50 postage. Orders for this volume should be placed through the Business Manager, The Canadian Field-Naturalist, Box 3264, Postal Station C, Ottawa, Ontario K1Y 4J5. Cheques for it should be payable to the Ottawa Field-Naturalists' Club.

FRANCIS R. COOK
Editor

Rediscovering America: Natural Areas in the 1990s

19th Annual Natural Areas Conference and the 14th Annual Meeting of the Natural Areas Association will be held on the Indiana University campus in Bloomington, Illinois, 27-30 October 1992. Since 1973 this conference has provided biologists, ecologists, natural resource managers, naturalists, and volunteers an opportunity to meet and exchange ideas on protecting, preserving, and managing rare species and significant habitats through presented papers, posters, field trips, and workshops.

Session topics will include: natural area conservation and protection (national and international); rare species inventory, management, monitoring and recovery; social aspects of natural area management; public land management; disturbances in natural systems; urban natural areas; natural area management (including exotics, visitor impacts, etc.); forest fragmentation; old growth forests; restoration of ecological communities; building big reserves; climatic change and other global issues; Great Lakes ecosystem.

This year's conference is co-sponsored by the Natural Areas Association and the Indiana Department of Natural Resources' Division of Natural Preserves. Cooperators include Hoosier National Forest Service, National Parks Service and The Nature Conservancy.

Members and nonmembers of the Natural Areas Association are encouraged to submit abstracts by 31 May 1992 to Cloyce L. Hedge at the address below. Details of format and topics are available.

Registration will be mailed in late July. Nonmembers may receive a brochure by contacting the address below.

MICHELLE L. MARTIN

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Restoring the Great Lakes: Indicator Species.

The concept of using indicator species, rather than chemical residue levels, put forward by Gilbertson (1988) as indicators of ecosystem health merit serious consideration. Nevertheless there are some limitations to all four of the species proposed by Gilbertson. The Bald Eagle (*Haliaeetus leucocephalus*) is sensitive to habitat change and it may well be that man's changes to the shoreline of the lower Great Lakes will prevent the re-establishment of the species however low the residue levels of organochlorines become. The Osprey (*Pandion haliaetus*), the earlier status of which in the Great Lakes Basin is uncertain, is more tolerant than the Bald Eagle of man's activities. But neither of these species are likely to be common enough or easy enough for detailed studies.

Neither the Mink (*Mustela vison*) or Otter (*Lutra canadensis*) are easy to study; for example, it is very difficult to determine their reproductive output. Again there is the problem of habitat change and in addition there is the question of pressure from trapping. Trapping records can be used as an estimate of population, but the various inborn biases obscure interpretation.

While a healthy population of these species throughout the Great Lakes Basin should be a goal, it is unlikely that this goal will "provide the catalyst for the final stringent clean-up required not only to protect a national symbol but also human health and future generations." The reason being that if a goal of say ten pairs of Bald Eagles with an average productivity of one young fledged per nest for the northern shore of Lake Ontario is not reached it can reasonably be argued by "pragmatic engineers and politicians" concerned with deficits before they spend billions for more strigent clean-up, that this is due to habitat change, electrocution on power lines, secondary poisoning from lead shot, accidental shooting, and so on. Fundamentally it is necessary to establish cause-and-effect rather than correlations. Except for the mink, where the basic toxicological data has been undertaken, this is going to be very difficult for the species under consideration.

The following additional approach proposed and relies on the systemic use of bioeffects markers as indicators of the health of the organism living in the natural environment. It is a clinical approach, comparable to that used in human medicine. If a good battery of physiological and biochemical tests is available, which cover the major functions of the organism then it should be possible to assess whether the parameters of the individual are within normal limits. Pragmatically this gives a specific defensible position as to whether, for this species, the environment is healthy. This approach gets around the problem of the effects of mixtures of chemicals, and of unknown chemicals in the environment. The limitations are that the battery of tests used may not be adequate, and that it is impossible to test all species. A similar approach could be used at the community and ecosystem level although the tools – such as measurement of energy and nutrient flow – for doing this are much less well developed.

Gilbertson stated that the Herring Gull is extraordinarily insensitive and concluded that although it should continue in use as a long-term monitor of trends in chemical levels, it should not be used as an indicator of the level of restoration needed. While this is correct as far as overall reproductive success is concerned this species still shows considerable biochemical abnormalities. The levels of hepatic porphyrin and mixed function oxidases are abnormally high and those of retinol abnormally low compared to marine colonies. These findings have been considered in more detail elsewhere (Peakall and Fox 1987).

The advantages of the Herring Gull as an indicator species for studies at the physiological and biochemical level are considerable. The species is common enough that adult gulls can be collected for measurement, experiments can be carried out on embryos both in the wild and in the incubator. Gulls can be maintained in captivity for experiments. For this species it is possible to obtain cause-and-effect relationships.

The second problem that needs to be addressed is to pin-point the source of the concern. This is not going to done using the Herring Gull or any other avian species because they are too mobile. However, results that have been obtained on the reproductive success, including the occurrence of abnormalities in the Snapping Turtle (*Chelydra serpentina*) (Bishop et al. 1991) suggest that this species could be used for this purpose and therefore should be added to the list of candidate indicators.

I would like to propose that the following criteria be met before we consider that no further clean-up of the Great Lakes is required:

1. That healthy populations of the Bald Eagle, Osprey, Mink and Otter occur throughout the Great Lakes Basin where there is suitable habitat.

2. That an agreed suite of biomarkers, which give information on the major physiological pathways, are within normal limits in the Herring Gull.

3. That for specific sites the reproductive capacity of the Snapping Turtle be normal.

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Reply to Restoring the Great Lakes: Indicator Species

Dr. Peakall has raised some excellent and valid points in his comment on my note (Gilbertson 1988) including the potential limitations of habitat availability and ease of data collection and interpretation for the four candidate species, Bald Eagle (*Haliaeetus leucocephalus*), Osprey (*Pandion haliaetus*), Mink (*Mustela vison*) and Otter (*Lutra canadensis*), as indicators of virtual elimination of persistent toxic substances in the Great Lakes basin. His proposal to use biochemical markers such as porphyrins, mixed function oxidase activity, and retinol storage in Herring Gulls (*Larus argentatus*) is a useful extension of this idea. The Snapping Turtle (*Chelydra serpentina*) is proving to be a useful monitor of local PCB pollution (Bishop et al. 1991).

There have been some significant advances since I published the note in 1988 both in evaluating these and other species and in our ability to infer cause-effect relationships (Fox 1991). The International Joint Commission (1991) has hosted a series of workshops on these various species to determine whether they can be used as practical indicators of virtual elimination of persistent toxic substances under the Great Lakes Water Quality Agreement. The species that seems to be the strongest candidate is the Bald Eagle (Best et al. 1990; Colborn 1991) followed, in some locations such as Georgian Bay, by the Osprey. The greatest advantage of the Bald Eagle is that there is an existing network of researchers who have been involved with the species for up to 25 years. Mink and Otter are not strong contenders at this time because researchers have been reluctant to undertake field surveys based on scats and spraints to establish presence and absence and Dr. Peakall has already pointed out the limitations of data on trapping for estimating populations (Wren 1991; Addison et al. 1991).

The Double-crested Cormorant (*Phalacrocorax auritus*) is fast becoming a more important monitor species than the Herring Gull, because so many of the significant advances in linking causes with effects have recently been made on this species (reviewed in Gilbertson et al. 1991). Similarly, the Lake Trout (*Salvelinus namaycush*) could become an important basinwide indicator (Mac and Edsall 1991), though researchers seem reluctant to make definitive statements about the role of persistent toxic substances in the demise of the species (Mac and Gilbertson 1990), and politically, many Great Lakes jurisdictions prefer to encourage exotic species such as Coho Salmon (*Oncorynchus kisutch*) for the sport fishery.

Finally, despite the well-explored advantages to be gained from initiating monitoring using biochemical indicators, it is proving difficult to generate the enthusiasm needed to gain acceptance of biochemical markers as measures of the restoration of the Great Lakes (International Joint Commission 1991). Part of the difficulty is to persuade people that they should be able to relate to a decrease in the measured activity of ethoxy resorufin *0*-deethylase in Herring Gull liver sections in the same way that they do relate to a return of the breeding population of Bald Eagles to the north shore of Lake Erie. A second difficulty is to gain acceptance from health researchers that biochemical markers in fish and wildlife have direct application in assessing the role of persistent toxic substances in causing subtle effects on reproduction and development of the human population that is most highly exposed through the Great Lakes food web (Swain 1991). Likely these difficulties are for discussion and resolution in the next five years.

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Erratum: Canadian Field-Naturalist 105(3)

In the News and Comment article of the last issue:

Components of the economic value of wildlife: An Alberta case study
W. L. ADAMOWICZ, J. ASAFU-ADJAYE,
P. C. BOXALL, and W. E. PHILLIPS
pages 423-429

nine lines were inadvertently omitted from the page proof (although present in the authors' galley) in the section discussing *Benefit Cost* and *Impact Analysis* on page 424. In the right hand column, fourth line, the sentence beginning "Furthermore,...." should read (with the omitted portion in boldface):

.... Furthermore, public sector agencies must **also consider nonmarket amenity values as they consider the benefits and costs associated with alternative natural resource uses including wildlife. Benefit-cost analysis can be a useful evaluation framework for such endeavors.**

Economic questions of resource use tradeoffs focus on gains (benefits) and losses (costs) associated with each use alternative. The concept of *economic efficiency* is at the center of this analysis. ...

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A Tribute To JAMES ALEXANDER CALDER, 1915 - 1990

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Cody, William J., and Jacques Cayouette. 1991. A tribute to James Alexander Calder, 1915-1990. Canadian Field-Naturalist 105(4): 584–591.

James (Jim) Alexander Calder was born in Regina, Saskatchewan on 26 March 1915, the son of James Alexander Calder. Jim came to Ottawa in 1927 when his father was appointed to the Canadian Senate. His interest in plants probably began during summer holidays at the family cottage at McGregor Lake in the Gatineau Hills north of the Ottawa River in Quebec, about 27 km NE of the city of Ottawa. Indeed, one of the early botanical publications in his personal library was Frère Marie-Victorin's *Flore Laurentienne* which bears the date "August 19th - '39" in his handwriting. At Ottawa he attended Ashbury College in Rockcliffe. He then attended McGill University in Montreal from 1934 to 1940 where he received his B.Sc. (Geology) and began work on his M. Sc. During a part of this time he was a summer assistant to Dr. Alice Wilson of the Geological Survey of Canada, working on a study of the geology of the Ottawa valley. This was the beginning of his work in the field. The Second World War ended Jim's university studies. On 20 August 1940 he joined the Royal Canadian Air Force where he served as a Flight Lieutenant Navigation Officer 'B' in Canada, Europe and India until his release on 10 January 1946. His fine service brought him the Distinguished Flying Cross, 1939-45 Star, Atlantic Star, Burma Star, Canadian Volunteer Service Medal with Clasp, War Medal 1939-45, and he was mentioned in Despatches. He was also awarded Operational Wings.

In the spring of 1946, Jim joined the herbarium staff of the Botany Section of the Botany and Plant Pathology Division, Science Service, Department of Agriculture at Ottawa. His desk was in a corner of the herbarium room on the second floor of the new wing of the old Botany Building which was located at the entrance to the Arboretum at the Central Experimental Farm. He worked in that building until he took early retirement on 23 June 1966.

During his service with the Botany Unit, Jim made over 37 600 collections of plant specimens, including many hundreds of duplicates. His collections were particularly notable, not only for their excellent quality, but also because of the detailed ecological data which accompanied them. The first set of his collections is preserved in Agriculture Canada's Centre for Land and Biological Resource Research Herbarium at Ottawa (DAO). Duplicate specimens were distributed to over 100 herbaria in Canada, the United States and around the world. These in turn brought many specimens from these institutions to enrich the Department's collection and thus help the research studies carried out by staff and visitors, both present and future. Of particular importance were his extensive collections of the genus *Carex*, in which he had a particular interest.

Jim's field work in botany began during the summer of 1946 in the area around Ottawa shortly after he joined the Botany Unit. At times he was accompanied by James (Jim) H. Soper (later professor at the University of Toronto and subsequently Chief Botanist at the National Museum of Canada in Ottawa) and John (Jack) M. Gillett (then a summer student, later on staff of the Botany unit, and subsequently Curator of Vascular Plants at the National Museum of Canada). The summer of 1947 was again spent in the Ottawa area. This year he was joined in the field again by Jack Gillett and William (Bill) J. Cody. His paper on *Utricularia* (1948) came as a result of these local field studies. He also, at the request of the Department's station at Ste.-Anne-de-la Pocatière on the south shore of the St. Lawrence River in Quebec, visited that area to study and collect the grasses thereabouts for a period of two weeks.

In 1948, the opportunity to work in Canada's north arose. In 1947 entomologists from the sister Entomology Division began a study of biting flies in the District of Keewatin. Several new areas were selected in 1948 and the entomologists requested the assistance of botanists to study the habitats in which the insects were breeding. This activity was to continue for several years. Jim spent the early part of the summer at Fort Chimo (now called Kuujjuaq) in northern Quebec and then moved to Frobisher Bay (now called Iqaluit) on Baffin Island where he took over from Harold A. Senn. Prior to leaving for the field that summer, however, he married Barbara Ney of Ottawa.

This initiation into Canada's north resulted in the reports written for the Defence Research Board (1949a,b,c) and led to later contributions on the flora of the Upper Frobisher Bay Region (1951a), Melville Peninsula (1951b), Chesterfield Inlet (1952b, with D. B. O Savile (mycologist)), and Ellesmere Island (1953a, with P. F. Bruggemann

Jim Calder botanizing in the mountains of British Columbia in 1956 (photo by Jack Parmelee).

(entomologist)), an incomplete manuscript with Bruggemann on the flora of the Mould Bay area of Prince Patrick Island, and an unpublished study with Savile entitled *Observations of Mosquito Distribution and Ecology based on the work of the Northern Insect Survey*.

During the summer of 1949 he botanized in Dawson in the Yukon Territory. It was here he first gained a familiarity with western plants. A student assistant, L. G. Billard, accompanied him. During his work in that region he met and worked with Jack Gillett, who had been assigned to botanize at Watson Lake and Whitehorse that summer, in the intervening area. In the summer of 1951, Jim was one of a party working on the Seward Peninsula of Western Alaska for a period of nearly four months. The summers of 1950 and 1952 Jim spent working out of Ottawa at various times with such colleagues as Bernard Boivin, Wilf Schofield, Bill Cody, D. B. O. (Doug) Savile, Gerald (Gerry) A. Mulligan and Jack Gillett.

Nineteen fifty-three was the beginning of Jim's work in the province of British Columbia. That summer he was accompanied by Doug Savile. Their first collection, *Fritillaria pudica*, was made near Crowsnest Pass on 11 May and their travels included such places as Osoyoos, Revelstoke, Upper Arrow Lake, Kamloops, Cranbrook, Vernon and Okanagan Falls. The following February he presented a memorandum to Harold A. Senn, the Head of the Botany Unit, entitled *Taxonomic, Floristic & Phytogeographic problems in British Columbia* (Appendix 5), in which he recommended extensive botanical studies in that province.

Then began a series of most productive long summers in the field in British Columbia: 1954, 1956, 1957, 1961, 1962 and 1964. On these surveys he was accompanied at different times by Doug Savile, Jack Gillett (summer student and later botanist), Roy L. Taylor (summer student and later botanist), J. (Jack) A. Parmelee (mycologist), K. T. MacKay (summer student), J. M. Ferguson (summer student) and Ken Spicer (botany technician). The years 1958 and 1959, when Jim was otherwise occupied, the British Columbia field work was carried out by Roy Taylor, accompanied by J. M. Ferguson the first year, and Gunther Staudt (botanist and specialist in the genus *Fragaria* from Germany) the next. The summer of 1960 was spent partly in extreme northern British Columbia, but mostly in southern Yukon Territory with Jack Gillett for the early part and Ilkka Kukkonen (botanist and mycologist from Finland) for the latter part, and in 1962 he also spent a short time at Trout Lake and Mt. Sedgewick in the eastern part of what is now Northern Yukon National Park with a Geological Survey of Canada field party. From these long summers in the field came his contributions to the understanding of western North American species of Saxifragaceae in the genera

Heuchera and *Saxifraga* (1959a,b, 1960a, with Savile) and his paper presented in Montreal at the IX International Botanical Congress on *Some Post-Pleistocene Migration Routes and Distribution Patterns in British Columbia* (1959d).

Prior to the meetings of the IX International Botanical Congress in Montreal in 1959, Jim participated in a field trip in the Banff National Park area. After the Congress, he was also fortunate to go on the arctic field trip which made stops at Great Whale River (8 August), Knob Lake (9 August), Frobisher Bay (10-11 August), Cambridge Bay (12 August), Resolute Bay (12 August), Coral Harbour (15-16 August), and Fort Chimo (17 August). Among those who took part in this most interesting excursion were a number of eminent botanists and mycologists such as Hugh M. Raup, Erling Porsild, Ilkka Kukkonen, D. B. O. Savile, B. A. Tikhomirov and O. Hedberg, thus giving Jim an opportunity to expand his horizons.

Summers when Jim was not in the west on extended trips, and even before and after these trips, he made a series of excursions, primarily in the Ottawa region and in southern Ontario. On these excursions he was accompanied at various times by such individuals as Bernard Boivin, Wilfred Schofield (summer assistant), David Erskine (summer assistant), Doug Savile, Bill Cody, Hubert Rhodes (botanist), Jack Gillett, Daphne Vick (summer assistant), Harry Mitchell (botany technician), Gerry Mulligan, and Bert Van Rens (botany technician). These names appear on the labels of the specimens they collected, many of which belonged to his special love, the genus *Carex*.

This love led to the description of a new species, *Carex raymondii* named after Marcel Raymond, well known caricologist at the Montreal Botanical Garden and to an extensive correspondence with other caricologists around the world to arrange exchanges in order to build and improve the *Carex* collection in the Vascular Plant Herbarium (DAO). His contribution (1953b, with Savile) to a new phylogeny of *Carex*, introducing a new subgenus *Kuekenthalia*, based on relationships with the Smut Fungi, was a milestone in the study of the genus. Later, his contribution to the cytology of *Carex* (1964a, with Moore) was the first to be based entirely on Canadian data.

In 1962 after having spent eight years in the field in the Cordilleran region of British Columbia, Yukon Territory and Alberta, Jim proposed a phytogeographical treatment of all of the seed plants and Pteridophytes to be found in the area. With this in mind he prepared a series of distribution maps which were to be the first fascicle of a series of publications. Unfortunately for him, the proposal was turned

Roy Taylor (left), Jim Calder (right), with a friend in 1956 (photo by Jack Parmelee).

down. Following this disappointment over a project on which he had worked so hard, Jim decided that he would give up the study of botany and after putting his collections in order, took early retirement on 23 June 1966.

Among his publications, the *Flora of the Queen Charlotte Islands Part 1* (co-authored with Roy Taylor) is probably the most important. This volume included sections on many aspects not treated in most floras: Botanical History, Physiography, Geology, Climate, Economic Botany, Plant Communities and Phytogeography. There are no descriptions, but the detailed discussions and comments on habitats, distribution, taxonomy and the treatments of other authors are invaluable. Related to this was the study of *Isopyrum* (Ranunculaceae) (1963, with Taylor), the study of *Subularia* (Cruciferae) (1964b, with Mulligan) and the taxonomic changes (1965a, with Taylor). Of his taxonomic papers, those on the genus *Saxifraga* (co-authored with Doug Savile) stand out.

Another aspect of Jim's life was his keen interest in postage stamps. This he inherited from his father who was an authority on early Canadian issues. Jim's particular interest was in early Spanish stamps. He received a gold medal for an exhibit of some of these at CAPEX '78 (*Canadian Philatelist* 41(4): 264, 1990).

For several years after his retirement Jim remained in Ottawa. During that time, in the summer months, he spent most of his time on a golf course. In 1973, however, he moved to the suburbs of Victoria, British Columbia, where he purchased a small bungalow on a very large lot. Here he started planting rhododendrons and over a period of years developed a rhododendron garden that was next to the best in the Victoria region and which was greatly admired by many visitors. In 1989, because of ill health, Jim returned to Ontario. He died at Trafalgar Memorial Hospital in Oakville on 14 February 1990. He is survived by three sons, John Alexander in Burlington, Ontario, James Andrew in Edmonton, Alberta and Marshall in Ottawa, Ontario.

Appendix 1: Publications of James A. Calder

1948. Two new records of *Utricularia* for the Ottawa District. Canadian Field-Naturalist 62: 164-165.

1949a. Report on the field work at Fort Chimo, Quebec, 1948. Appendix 'B' in Part III Botanical Associations of the Northern Biting Flies of Entomological Research in Northern Canada Progress Report. Defence Research Board, Canada Report Number D.R. 20. 21 pages.

1949b. Report on the field work at Frobisher Bay Baffin Island, 1948. Appendix 'C' in Part III Botanical Associations of the Northern Biting Flies of Entomological Research in Northern Canada Progress Report. Defence Research Board, Canada Report Number D.R. 20. 38 pages.

1949c. Report on experimental plantings of cereals. Appendix 'F' in Part III Botanical Associations of the Northern Biting Flies of Entomological Research in Northern Canada Progress Report. Number D.R. 20. 7 pages.

1951a. Plants from the Upper Frobisher Bay Region, Baffin Island, N.W.T., Canada. Canadian Field-Naturalist 65: 47-60.

1951b. Vascular Flora of the Melville Peninsula, Franklin District, N.W.T. Canadian Field-Naturalist 65: 180-184.

1952a. Notes on the genus *Carex* I: A new species of *Carex* from western Canada [*Carex raymondii*]. Rhodora 54: 246-250.

1952b. [Savile, D. B. O., and J. A. Calder]. Notes on the flora of Chesterfield Inlet, Keewatin District, N.W.T. Canadian Field-Naturalist 66: 103-107.

1953a. Bruggemann, P. F., and J. A. Calder]. Botanical investigations in Northeast Ellesmere Island, 1951. Canadian Field-Naturalist 67: 157-174.

1953b. [Savile, D. B. O., and J. A. Calder]. Phylogeny of *Carex* in the light of parasitism by the smut fungi. Canadian Journal of Botany 31: 164-174.

1959a. [and D. B. O. Savile]. Studies in Saxifragaceae – I. The *Heuchera cylindrica* complex in and adjacent to British Columbia. Brittonia 11: 49-67.

1959b. [and D. B. O. Savile]. Studies in Saxifragaceae – II. *Saxifraga* sect. *Trachyphyllum* in North America. Brittonia 11: 228-249.

1959c. *Review of:* Chapman –Spring Flowers of the Lower Columbia River." Canadian Field-Naturalist 73: 57.

1959d. Some Post-Pleistocene migration routes and distribution patterns in British Columbia. Proceedings of the IX International Botanical Congress, Montreal, 2: 57.

1960a. [and D. B. O. Savile]. Studies in Saxifragaceae – III. *Saxifraga odontoloma* and *lyallii*, and North American subspecies of *S. punctata*. Canadian Journal of Botany 38: 409-434.

1960b. *Review of:* Hitchcock, Cronquist and Ownbey –Vascular Plants of the Pacific Northwest Part 4: Ericaceae through Campanulaceae." Canadian Field-Naturalist 74: 56.

1963. [and R. L. Taylor]. A new species of *Isopyrum* endemic to the Queen Charlotte Islands of British Columbia and its relation to other species in the genus. Madroño 17: 69-76.

1964a.. [Moore, R. J.and J. A. Calder]. Some chromosome numbers of *Carex* species of Canada and Alaska. Canadian Journal of Botany 42: 1387-1391.

1964b. [G. A. Mulligan and J. A. Calder]. The Genus *Subularia* (Cruciferae). Rhodora 66: 127-135.

1965a. [and R. L. Taylor]. New taxa and nomenclature changes with respect to the flora of the Queen Charlotte Islands, British Columbia. Canadian Journal of Botany 43: 1387-1400.

1965b. *Review of:* Hitchcock, Cronquist and Ownby –Vascular Plants of the Pacific Northwest, Part 3 and Part 2." Canadian Field-Naturalist 79: 204-205.

1968. [and R. L. Taylor]. Flora of the Queen Charlotte Islands Part 1, Systematics of the Vascular Plants. Research Branch, Canada Department of Agriculture, Monograph Number 4, Part 1. 659 pages.

Appendix 2: Taxa named in honour of James A. Calder

Adiantum pedatum L. subsp. *calderi* Cody, Rhodora 85: 93. 1982.

Aster calderi Boivin [*A. puniceus* L. var. *calderi* (Boivin) Lepage], Canadian Field-Naturalist 65: 14. 1951.

Carex calderi Boivin (*C. curta* X *heleonastes*), Naturaliste canadien 94: 522. 1967.

Carex jimcalderi Boivin (*C. leptalea* Wahl. subsp. *pacifica* Calder & Taylor), Phytologia 43: 67. 1979.

Cintractia calderi Savile, Canadian Journal of Botany 29: 324. 1951 [*Anthracoidea calderi* (Savile) Kukkonen, Annales Botanici, Societatis Botanicae Fennicae 'Vanammo' 34: 73. 1963.]

Equisetum calderi Boivin, American Fern Journal 50: 107-8. 1960.

Lesquerella calderi Mulligan & Porsild, Canadian Journal of Botany 47: 215-6. 1969.

Ligusticum calderi Mathias & Constance, Bulletin of the Torrey Botanical Club 86: 374. 1959.

Appendix 3: New taxa described by James A. Calder (et al.)

Arenaria rubella (Wahlenb.) Sm. f. *plena* Calder f. nov. in B. Boivin. Canadian Field-Naturalist 65: 4. 1951.

Calamagrostis purpurascens R.Br. subsp. *tasuensis* Calder & Taylor subsp. nov., Canadian Journal of Botany 43: 1388. 1965.

Carex leptalea Wahlenb. subsp. *pacifica* Calder & Taylor subsp. nov., Canadian Journal of Botany 43: 1391. 1965.

Carex raymondii Calder sp. nov. [*C. atratiformis* Britton subsp. *raymondii* (Calder) Pors.; *C. atrata* L. var. *raymondii* (Calder) Löve & Löve], Rhodora 54: 246-7. 1952.

Cassiope lycopodioides (Pall.) Don subsp. *cristapilosa* Calder & Taylor subsp. nov., Canadian Journal of Botany 43: 1397. 1965.

Geum schofieldii Calder & Taylor sp. nov., Canadian Journal of Botany 43: 1394. 1965.

Heuchera x *easthamii* Calder & Savile hybr. nov. (*H. chlorantha* x *H. micrantha* var. *versifolia*), Brittonia 11: 54. 1959.

Isopyrum savilei Calder & Taylor sp. nov., Madroño 17: 70. 1963.

Kuekenthalia Savile & Calder subgen. nov., [*Carex*], Canadian Journal of Botany 31: 171. 1953.

Lloydia serotina (L.) Reichenb. subsp. *flava* Calder & Taylor subsp. nov., Canadian Journal of Botany 43: 1392. 1965.

Mimulus guttatus DC. subsp. *haidensis* Calder & Taylor subsp. nov., Canadian Journal of Botany 43: 1398. 1965.

Pedicularis pennellii Hult. subsp. *insularis* Calder & Taylor subsp. nov., Canadian Journal of Botany 43: 1399. 1965.

Ranunculus hyperboreus Rottb. f. *integrescens* Savile & Calder f. nov., Canadian Field-Naturalist 61: 105. 1952.

Saxifraga caespitosa L. f. *multiflora* Calder f. nov., Canadian Field-Naturalist 65: 183. 1951.

Saxifraga lyallii Engler var. *hultenii* Calder & Savile var. nov., Canadian Journal of Botany 38: 418. 1960.

Saxifraga punctata L. subsp. *carlottae* Calder & Savile subsp. nov., Canadian Journal of Botany 38: 423-4. 1960.

Saxifraga punctata L. subsp. *cascadensis* Calder & Savile nom. nov., Canadian Journal of Botany 38: 425. 1960.

Saxifraga punctata L. subsp. *porsildiana* Calder & Savile subsp. nov., Canadian Journal of Botany 38: 429-30. 1960.

Saxifraga taylori Calder & Savile sp. nov., Brittonia 11: 249. 1959.

Saxifraga tricuspidata Rottb. f. *ligulata* Savile & Calder f. nov., Canadian Field-Naturalist 66: 105-6. 1952.

Saxifraga tricuspidata Rottb. f. *woodruffii* Calder f. nov in W. J. Cody, Canadian Field-Naturalist 64: 92. 1950.

Senecio cymbalarioides Nutt. subsp. *moresbiensis* Calder & Taylor subsp. nov., Canadian Journal of Botany 43: 1399. 1965.

Subularia aquatica L. subsp. *americana* Mulligan & Calder subsp. nov., Rhodora 66: 132. 1964.

Viola biflora L. subsp. *carlottae* Calder & Taylor subsp. nov., Canadian Journal of Botany 43: 1395. 1965.

Appendix 4: Taxonomic transfers by James A. Calder (et al.)

Adiantum pedatum L. subsp. *aleuticum* (Rupr.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1388. 1965.

Arctostaphylos uva-ursi (L.) Sprengel subsp. *adenotricha* (Fern. & Macb.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1397. 1965.

Arenaria peploides subsp. *major* (Hook.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1393. 1965.

Botrychium lunaria (L.) Sw. subsp. *minganense* (Vict.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1388. 1965.

Callitriche heterophylla Pursh ex Darby subsp. *bolanderi* (Hegelm.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1395. 1965.

Calypso bulbosa (L.) Oakes subsp. *occidentalis* (Holz.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1393. 1965.

Carex arenicola Schmidt subsp. *pansa* (L. H. Bailey) Koyama & Calder comb. nov., Canadian Journal of Botany 43: 1389. 1965.

Carex canescens L. subsp. *arctaeformis* (Mackenzie) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1389. 1965.

Carex deweyana Schw. subsp. *leptopoda* (Mackenzie) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1389. 1965.

Carex leptalea Wahlenb. subsp. *harperi* (Fern.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1391. 1965.

Carex mertensii Prescott subsp. *urostachys* (Franchet) Calder & Koyama comb. nov., Canadian Journal of Botany 43: 1392. 1965.

Corallorhiza maculata Raf. subsp. *mertensiana* (Bong.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1393. 1965.

Cornus intermedia (Farr) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1396. 1965.

Dodecatheon pulchellum (Raf.) Merrill subsp. *cusickii* (Greene) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1398. 1965.

Douglasia laevigata A. Gray subsp. *ciliolata* (Constance) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1398. 1965.

Draba lonchocarpa Rydb. subsp. *kamtschatica* (Ledeb.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1393. 1965.

Equisetum hyemale L. subsp. *affine* (Engelm.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1387. 1965.

Franseria chamissonis Less. f. *bipinnatisecta* (Less.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1399. 1965.

Habenaria unalascensis (Spreng.) S. Wats. subsp. *elata* (Jepson) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1393. 1965.

Habenaria unalascensis (Spreng.) S. Wats. subsp. *maritima* (Greene) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1393. 1965.

Heuchera cylindrica Dougl. var. *orbicularis* (R.B. & L.) Calder & Savile stat. nov., Brittonia 11: 58. 1959.

Hieracium triste Willd. ex Sprengel subsp. *gracile* (Hook.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1399. 1965.

Kalmia polifolia Wang. subsp. *microphylla* (Hook.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1398. 1965.

Ligusticum scoticum L. subsp. *hultenii* (Fern.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1396. 1965.

Lycopodium sabinaefolium Willd. subsp. *sitchense* (Rupr.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1387. 1965.

Lycopodium selago L. subsp. *miyoshianum* (Makino) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1388. 1965.

Lycopodium selago L. subsp. *patens* (Beauv.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1388. 1965.

Menziesia ferruginea Smith subsp. *glabella* (A. Gray) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1398. 1965.

Moneses uniflora (L.) Gray subsp. *reticulata* (Nutt.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1397. 1965.

Pinguicula vulgaris L. subsp. *macroceras* (Link) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1399. 1965.

Polystichum braunii (Spenner) Fée subsp. *alaskense* (Maxon) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1388. 1965.

Polystichum braunii (Spenner) Fée subsp. *andersonii* (Hopkins) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1388. 1965.

Polystichum braunii (Spenner) Fée subsp. *purshii* (Fern.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1388. 1965.

Potamogeton berchtoldii Fieber subsp. *tenuissimus* (Mert. & Koch) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1388. 1965.

Potamogeton epihydrus Raf. subsp. *nuttallii* (Cham. & Schlect.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1388. 1965.

Potentilla hyparctica Malte var. *hyparctica* f. *tardinix* (Polunin) Savile & Calder comb. nov., Canadian Field-Naturalist 66: 106. 1952.

Ranunculus hyperboreus Rottb. f. *turquetilianus* (Polunin) Savile & Calder stat. nov., Canadian Field-Naturalist 66: 105. 1952.

Sanguisorba canadensis L. subsp. *latifolia* (Hook.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1395. 1965.

Sanguisorba officinalis L. subsp. *microcephala* (Presl) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1395. 1965.

Saxifraga lyallii Engl. subsp. *hultenii* (Calder & Savile) Calder & Savile comb. nov., Canadian Journal of Botany 43: 1393. 1965.

Saxifraga tricuspidata Rottb. f. *micrantha* (Sternb.) Calder & Savile comb. nov., Brittonia 11: 243. 1959.

Sorbus sitchensis M. Roemer subsp. *grayi* (Wenzig) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1395. 1965.

Spiraea douglasii Hook. subsp. *menziesii* (Hook.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1395. 1965.

Streptopus streptopoides (Ledeb.) Frye & Rigg subsp. *brevipes* (Baker) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1393. 1965.

Trisetum cernuum Trin. subsp. *canescens* (Buckl.) Calder & Taylor comb. nov., Canadian Journal of Botany 43: 1389. 1965.

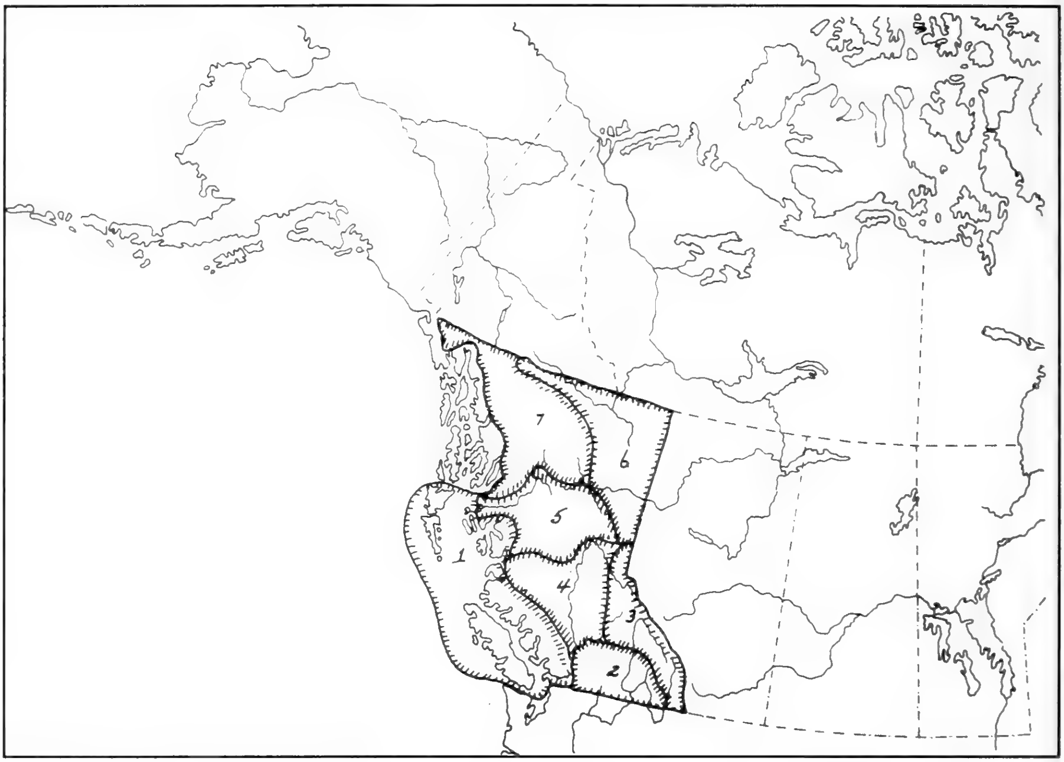
Appendix 5: Taxonomic, Floristic & Phytogeographic problems in British Columbia.

The following text was submitted to Dr. Harold A. Senn, Head Botany Section, Botany and Plant Pathology Division by James A. Calder in February 1954, as proposal for future field studies.

On the basis of a survey of the British Columbia material in the divisional herbarium it is felt that detailed studies whether floristic, monographic, or phytogeographic are not warranted at the present time. The lack of material in almost every species would be a considerable handicap regardless of the problem tackled. It seems logical that a number of general surveys should be carried out at first, at least in the more accessible areas. On the attached outline map an attempt has been made to divide the province into seven areas, each of which (with the exception of No. 6) could be covered in a single year if the entire growing season was spent in the field. The boundaries of the areas chosen are occasionally arbitrary, but where possible they encompass regions which are similar floristically. Admittedly much would be missed as the areas chosen are too large for detailed work in a single season. The accumulated material, however, would serve as a basis for any detailed survey in a limited area, and many of the floristic and phytogeographic problems could be undertaken.

At the present time complete floras are available or floras are in the process of preparation for all the Canadian provinces with the exception of New Brunswick and British Columbia. The type of survey as outlined would result in the accumulation of a large amount of material which could serve as a basis for a worthwhile revision of Henry's –Flora of Southern British Columbia" (1915), and could include as well, the northern section which was not taken into account by Henry. I understand that Dr. [T. M. C.] Taylor is at present preparing an abbreviated flora of the province for the Gage Publishing Co. along the lines of the now out of date –Wild Plants of Canada" by Spotton, Cosens and Ivey (1926). If eventually a revision of Henry's flora were undertaken I do not believe there would be any clash with provincial personnel.

In comparison with the rest of the provinces, the flora of British Columbia is complex when taken as a whole and its



Proposed survey areas in British Columbia for study of taxonomic, floristic and phytogeographic problems.

flora is considerably larger. In checking Henry (1915) it is found he has recorded 1990 species and it is estimated that Eastham's supplement (1947) contains a further 450 additions for a total flora of 2440. As little work has been done along the B.C. – Yukon border and as many of the eastern elements from the triangle in the northeastern section have not been recorded it is estimated that the flora is in the vicinity of 3000 species. As pointed out previously the type of survey suggested could serve as a basis for a revision of Henry's flora, but its completion would require considerably more time than has already been spent by Boivin in Saskatchewan or Scoggan in Manitoba, where there is a limited flora. In any event regardless of whether a flora is eventually prepared or not, a number of well worthwhile projects could be undertaken.

1. *Monographic studies*

These could be carried out in some of the smaller genera and sections of genera. A number of problems have already arisen from the 1953 survey and it is eventually hoped to monograph:

(a) The section *Atratae* of *Carex* in North America.

(b) The alpine members of the section *Ovales* of *Carex* in North America.

Papers are also contemplated in such genera as *Saxifraga*, *Heuchera* and *Antennaria*.

2. *Floristic Studies*

There are a number of areas where detailed floristic studies should eventually be undertaken:

(a) The grassland-range country centering around Kamloops and along the Fraser River valley south of Williams Lake.

(b) The range land and fruit growing areas of the Similkameen, Okanagan, Kettle River and East and West Kootenay River valleys.

(c) The lower Fraser River valley in the Coastal Forest region.

A comparison of the floras of the alpine areas of the coastal belt, the Interior Plateau and the Rockies would also be of interest and would help to solve problems relating to local Pleistocene glaciation and post-Pleistocene plant migration.

A series of papers might be written dealing with individual genera or families which could include keys, descriptions, ecological notes, etc.

3. *Phytogeographic Studies*

Raup (1947) in a recent paper entitled –Some natural floristic areas in boreal America" discusses the geographic affinities of the Brintnell Lake flora. In relation to his discussion he has plotted the distribution of many of the Cordilleran, Alaska-Cordilleran, Arctic-Alpine, etc., species in western and northwestern America. The northern limit and distribution of many of the Sonoran elements of the Interior Plateau are little known. A study of the post-Pleistocene migration of these elements would be well worthwhile. The problem is complicated as little is known of the extent of glaciation during the Pleistocene in the interior of British Columbia.

If field work is to be continued in British Columbia this coming summer, Dr. Savile and myself would like to carry out a survey in Area 5 (as outlined) from approximately July 1 to September 15. As there are a number of problems resulting from the field work in 1953 which involve species

(in the genera *Saxifraga*, *Heuchera*, *Carex*, etc.) whose main distribution is south of the province, we would like to proceed to Prince George via northern Montana, Idaho and Washington.

Area 1: Includes Vancouver Island, the adjacent mainland, and the lower Fraser Valley as far east as Hope. This area is all within the Coast Forest region and has the largest flora of the seven areas. It should be the last area surveyed. A short period should be spent at the herbaria of the Provincial Museum and the University of British Columbia during this summer. Possibly two seasons would be required in this region.

Area 2: Includes an area bounded by Hope, Lytton, Kamloops, Revelstoke, Cranbrook, Trail, and Keremeos. This area was surveyed in the summer of 1953. If further field work is carried out in this region special attention should be paid to the grassland areas along the B.C.-U.S.A. border, the Ashnola Range south of Keremeos, and to the Alpine and Sub-alpine areas bordering the Okanagan Valley.

Area 3: Includes the Rocky Mountain Trench and the Rockies. A very brief survey was carried out in the southern part of the –trench" this past summer. The areas adjacent to Waterton National Park and Flathead Valley on the Montana - B.C. boundary have never been surveyed, and little is known of the northern section. Field work should be concentrated in these areas.

Area 4: Includes the native grasslands of the Chilcotin, Fraser and Thompson watersheds, and parts of the Coast, Montane, Sub-alpine and Columbia Forest Regions. Any survey would of necessity be concentrated in the grassland belt along the main highway, between Cache Creek and Prince George using Quesnel and Williams Lake as headquarters. The Coast Forest could be reached at Bella Coola, and the Columbia Forest in the Quesnel Lakes area.

Area 5: Includes elements of the Coast, Sub-alpine and Montane Forest regions. Although grasslands are not indicated for this area it is likely that there are prairie remnants along the main river systems. The survey in this region should be concentrated along the Prince George-Prince Rupert Highway with an occasional survey along the Prince George-Dawson Creek, and Prince George-McBride roads.

Area 6: Includes the Boreal Forest Region east of the Rockies in the north-east corner of the province. The survey would of necessity be concentrated along the Alaska Highway between Dawson Creek and Watson Lake, and the road systems in the Dawson Creek and Fort St. John areas.

Area 7: This area is for the most part inaccessible. We have a few miscellaneous collections from the Bennett Lake area (Gillett & Mitchell), and from Atlin Lake (Aitken). We will be receiving further material from Aitken, who is preparing a geological map of the area, this coming fall. If D.R.B. funds are available it might be well worthwhile placing someone at Telegraph Creek or Dease Lake for a summer.

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Received 9 January 1991

A Tribute to STANLEY WARREN GORHAM, 1917 - 1984

FRANCIS R. COOK

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Cook, Francis R. 1991. A tribute to Stanley Warren Gorham, 1917 -1984. Canadian Field-Naturalist 105(4): 592–596.

Stanley Warren Gorham, photographed by Don E. McAllister in Ottawa, Ontario, about 1979.

On 23 March 1984, Stan Gorham lost a prolonged battle with a succession of heart problems and died in hospital in Halifax, Nova Scotia. At his request there was no memorial service. He was cremated and his ashes returned to his native New Brunswick for a quiet family ceremony on the hill behind his home at Browns Flat.

Advance word of his critical condition had done nothing to prepare his friends. He had long established that he could confront and dismiss difficulties on his own terms; to many of us he seemed indestructible. A tough ex-seafarer, a Loyalist of the old school, Stan was uncompromising, self-made, self-deprecating, warm, sympathetic, and generous. He had grown up in, and accepted, a setting where a man was still measured by the quantity he could drink and the severity of the blows he could deliver and receive. A delightful storyteller (though not always for parlour-room company) he had prodigious recall and deep appreciation and respect for the past generation of scientists, particularly herpetologists. He radiated a desire to collect, classify and catalogue and he was drawn to museums like a magnet. He became a meticulous and dedicated scholar who was unfailingly patient and always had time to encourage anyone's interest in vertebrate animals, especially amphibians. Stan instinctively treated all he met, regardless of their age, education, or position, with low-key humorous sallies, obvious respect for their individual opinions, and an infinite willingness to listen to their problems without intruding with his own. There is an international legion of those of us who miss him greatly, both in scientific circles and among those not, or barely, even aware that scientific circles exist, much less that Stan was part of them.

In 1975, the University of New Brunswick awarded him the honorary degree of Doctor of Science, summing up with:

> Stanley Warren Gorham has created an eminent place for himself among our Canadian naturalists, as administrator, author and researcher, and, in so doing, leaves us in his debt.

On 15 August 1984, the New Brunswick Museum unveiled a permanent plaque placed in the museum to honour him which read:

> Dr. Stanley W. Gorham 1917-1984 Curator Emeritus Department of Science 1965-1983. In recognition of dedicated service to the New Brunswick Museum and contributions to the scientific and popular understanding of the natural history of the province. Erected by the Board and Staff, 1984.

Stan was from Browns Flat, Kings County, New Brunswick, in the heart of the United Empire Loyalist settlements of the Saint John River Valley between Saint John and Fredericton. He was born 22 November 1917 to Warren and Jennie (Patterson) Gorham. He grew up on a farm in the region where there had been Gorhams since New Brunswick was created. His life-long interest in nature showed early. As a small boy he made a scrapbook of his favourite columns by Thorton W. Burgess. The Saint John Telegraph-Journal ran these *Burgess Bedtime Stories* daily and Stan was not the only one of his, or later, generations whose thirst for nature study was initially stimulated by them. In the spring it was not uncommon, according to family oral history, for him to have a frog or two, or a snake, in his pocket while at school.

School work came quite easily to him, he had an exceptionally fine memory. But he could not resist clowning, and his teacher, after he had hidden her slippers one very wet day so that she had to sit at school with wet boots and subsequently contracted a bad cold, dismissed him for a month. This was before the Grade 8 High School entrance exams (an important and real hurdle in those days) and the teacher said Stan need not bother writing them. In fact she may have indicated in a frank note to his parents that he might better be started on whatever way he was going to support himself for life without further waste of the school's time. She would not be the last administrator to misjudge him. He studied at home and wrote the exams anyway, coming second in the district at the Consolidated School. Although he went on and completed to grade 10, grade 11 was matriculation in New Brunswick at that time.

Years later, as a veteran of the Second World War, he was eligible for government support to pick up his lost education. He might, like many others of his generation, have seized this opportunity and gone on to the university degrees previously denied them by youthful temperament or circumstances. But he was soon raising a family that always remained first in his priorities. Perhaps he was deterred by bad council that the level of support offered was too low, the road to higher education too hard and too long and his start too late.

Before the war Stan worked in the woods and as a casual worker for Canadian National Railways. When the war came he enlisted in the Royal Canadian Air Force Marine Squadron and completed four years at sea on supply boats. He often would recount stories of the bravery of others and the dangers they had faced, but only under determined questioning would he reveal that he had spent time on munitions ships where at any moment a single well-placed enemy shell might have erased all aboard with little chance to ever demonstrate their fitness under fire.

Stan had studied after duty to qualify for First Mate's papers. It was typical of him that he delighted in recalling the gruelling written exam, held under the imposing and watchful eye of a weathered veteran Captain. Having worked through the major question on the paper, a long and complicated one ending

with the plotting of a hypothetical ship's present position, Stan realized to his horror as the exam time neared an end that his answer placed the ship soundly aground on a sand bar, a position into which no one expecting to qualify as a mate should ever have placed his vessel. The examiner noted his perplexed look and stopped to ask if Stan was having particular difficulty with the paper. Downcast, Stan admitted this was true, he was aground, and began a last attempt to rework the problem in the time left. The Captain curtly snapped "Mr. Gorham, this is an exam !". Stan was momentarily stung, believing his frankness had been taken as an unforgivable plea for help with the question. Suddenly, it dawned on him that the gruff reprimand was actually a reassurance – an exam does not have to depict a real situation. His impossible answer was the correct one. The achievement of his First Mate's papers he always regarded with justified pride.

During his war service Stan took advantage of the travel to visit museums and meet curators whenever he was in a port. These contacts lead him to conceive of undertaking an up-to-date checklist of the amphibians of the world, complete with synonymies. There were monographs for many families and genera and faunal works for regions but the last complete listing of all world amphibians were the British Museum catalogues by G. A. Boulenger in 1882.

He may have received some early encouragement from his European contacts, but when he tried to discuss it with American herpetologists after the war he received a rude rebuke from some that he never forgot. One replied to a letter in which he had outlined his idea with the simple advice that he should forget it, he had neither the background nor the education to tackle such a project, and the clear implication was made that he would never have it. The strong impression was given that the American museums already had their own working lists and these served the established people quite well enough.

There is, however, some underlying tenacity in people from the Maritime Provinces of Canada; once they find a clearly defined goal that suits them, they may ignore both magnitude and time. Stan began working on the list in 1947. For 23 years he painstakingly sifted through the world amphibian literature and corresponded widely, including many American herpetologists with whom he soon established excellent rapport.

It was no easy task. Stan soon had a growing family to provide for and no qualifications for obtaining an academic job. After the war he worked, for six months in 1946, as a taxidermist at Oliver Spanner's Taxidermy Shop in Toronto. He returned home and laboured as a longshoreman in Saint John and at woods work in the winter months and for Kierstead's Florists in Browns Flat during the summer. Then he won a competition for a technician position with the Zoology Division of the National Museum of Canada in Ottawa, joining its staff in January 1953. He had been chosen partly on the strength of his taxidermy experience which he had sought to prepare himself for a future in museum work, partly on his obvious and sustained interest in natural history. A recommendation from the highly regarded Austin Squires at the New Brunswick Museum in Saint John, who knew and appreciated Stan, probably also helped.

But museum technicians were not highly paid and Stan soon took on an additional night job with an office-cleaning firm to supplement his income. The work for the amphibian checklist was fitted in at lunch-hours, spare hours after completing the second job, and weekends. I often think now of Stan when I hear myself saying I could not tackle or complete a certain task because of other demands on my time, and it is humbling to say the least.

Stan collected in every province and territory of Canada except the Yukon. While with the National Museum, he participated in many field survey expeditions as these were, at that time, still an accepted and enervating part of museum routine. He went to southern British Columbia with the Curator of Ornithology, W. Earl Godfrey, in 1955; to the arctic with the Curator of Fishes, Don E. McAllister, in 1964; and across northern Ontario to Alberta with me for amphibians and reptiles in 1965. He took six trips on Fisheries Research Vessels, collecting invertebrates, fish and some seabirds, five on the east coast and the other on the west.

Two years before he left the National Museum he became the first technician appointed for ichthyology and herpetology and, a year afterwards, the first for herpetology alone. This came too late for the National Museum to benefit fully. He had received an offer from the New Brunswick Museum in Saint John, and because the family farm, vacant since the death of his father, lay within commuting distance, he could provide better support for his family if he returned to his native province than he could in Ottawa. In addition, he would now have a better opportunity to develop his own projects. Stan joined the New Brunswick Museum in July 1965 as Assistant Curator of National Sciences, was later promoted to Curator of Vertebrate Zoology, and later still to Acting Head of the Natural Sciences Department as well. After he retired in November 1982 at age 65, he was appointed Curator Emeritus.

While at the New Brunswick Museum Stan had opportunities for travel beyond Canada. In January-March 1966, a trip to Fiji and Australia was made possible by support from the American Philosophical Society, and he was able to investigate Fiji's two endemic frogs in the field. In 1967, he undertook an expedition jointly financed by the National and New Brunswick museums to the Falkland Islands to col-

lect fish, marine invertebrates and birds. This one trip, unfortunately, affected him for the remainder of his life. He contracted parrot fever (psittacosis) sometime during it and this weakened his immune system and contributed to progressive erosion of his health in later years. In 1970 he went to Brazil from August to October on a grant from the National Research Council of Canada to work on the frog collections in the Sao Paulo and Rio de Janeiro museums, but his plans for a longer stay were thwarted by poor health. What Stan may have regarded a the high point of his travels was his last trip. On a grant from the National Research Council of Canada he was able to visit the USSR in 1978 to study palaearctic amphibians and discuss a variety of taxonomic and distributional problems with outstanding researchers, among them Ilya Darevsky and Leo Borkin at the Academy of Sciences in Leningrad.

Stan's first published contribution was on the Four-toed Salamander, *Hemidactylium scutatum*, and appeared in *The Canadian Field-Naturalist* (Gorham 1955). J. Sherman Bleakney was Curator of Herpetology at the National Museum at that time; he arrived at the museum one Monday morning in the spring of 1954 to find a bottle on his desk with a live example of this species in it. Four-toed Salamanders were then recorded in Canada only from central and western Ontario and from Nova Scotia. There was no label in the jar, and although the sudden appearance of a live specimen indicated local capture, it could have been dropped off to the office by anyone. Bleakney was a study of barely controlled curiosity and frustration until Stan appeared and casually remarked, “Find anything interesting today, Sherm?” Not casually enough, the wide grin followed too quickly. Gradually, under verbal pressure, he admitted to being the source and allowed information on the unexpected new locality to be coaxed from him. As the first record for Quebec, it was important to Bleakney's then current pioneering work on the zoogeography of amphibians and reptiles of eastern Canada. The find had not surprised Stan; he had been maintaining for some time that there appeared to be ideal habitat for these salamanders in the area and had searched it with the full expectation of success.

While Stan was at the National Museum the first synthesis based on his still growing comprehensive checklist manuscript came out as an analysis of the comparative numbers of amphibians in different parts of the world, published in *The Canadian Field-Naturalist* (Gorham 1957, 1962, 1963). Robert Mertens and Heinz Wermuth in Europe took notice of his project and invited him to contribute sections to the prestigious German series *Das Tierreich*, recently resurrected after war and post-war dormancy. Here, his first instalment of the amphibian checklist, on the Caecilians, appeared (Gorham 1962). Unfortunately, it was almost immediately out-of-date. E. H. Taylor published his monumental revision, restructuring the classification of the entire group, shortly afterward. Stan only published one other part of the amphibian checklist in *Das Tierreich*, that covering the frogs of the families Ascaphidae, Liopelmatidae, Pipidae, Discoglossidae. Pelobatidae, Leptodactylidae, and Rhinophrynidae (Gorham 1966). The usefulness of the checklist project had by then attracted the attention of specialists in other amphibian families and they demanded participation to give it the benefit of their experience, including that from the type comparisons that Stan had not had the travel resources to undertake. Some produced totally new versions of Stan's manuscript list for groups in which they specialized. The New Brunswick museum later published his checklist for all amphibia (Gorham 1974).

Though a few herpetologists were critical of Stan's work, their main points were often of omissions that were inevitable in a compilation of this magnitude, as for example, J. D. Lynch and A. Schwartz (1971, *Journal of Herpetology* 5(3-4): 113) “Gorham, not a herpetologist...” whose curt judgement hardly was valid.

Stan did attain a breadth of literature knowledge necessary for the task he had set himself. Sherman Bleakney has recalled Stan's ability to retain detail: no matter what amphibian might be mentioned in a conversation Stan could spontaneously recite an appropriate reference, author, journal, date, and often the very page. Positive correspondence on the his checklist was voluminous. The noted French herpetologist, Alain Dubois, in a review (*Copeia* 1987: 831-832) of the 1985 University of Kansas contribution *Amphibian Species of the World*, compared and contrasted it with Stan's earlier (1974) publication. While clearly conceding that some criticisms of Stan's work were well-founded, he points out that, although the 1974 list was the work of only one man, it was nevertheless extremely useful. He recommended it as a good companion which should be used with the 1985 compilation to compensate for what he regarded as the numerous mistakes or omissions in the latter.

Stan's Loyalist roots may have been disproportionately sensitive to Yankee criticism. Although privately social, he was publicly shy, and I can not recall his ever presenting an oral paper. He did not attend many American herpetological conferences. I remember only two that we both were at. In 1972, at the American Society of Ichthyologists and Herpetologists meetings in Boston he was especially reserved whenever an exchange on errors and opinion between others seemed to become ruthless “quality control” of a sort that typifies the heart and soul of some concerned and justly respected, prominent members of the American herpetological communi-

ty. Eagerness to voice critical capacity can sometimes appear to ignore the fine line between the desire for improvement of standards and the destruction of any opposing views, at least to those not continually bathed in this dynamic atmosphere. At the Ottawa meetings in 1974, where there were more Canadians, he was more comfortable. He was even more at ease with the dignity and old-world courtesy of established European herpetologists who had given him unfailing encouragement.

His tenacity did help catalyze a general realization of the broad usefulness and audience for detailed group reference checklists. Growing conservation interest, the signing by 110 countries of the Convention on International Trade in wild fauna and flora (CITES), and increased awareness of the accelerating loss of biodiversity despite these positive advances, all have accentuated the need for compilations. It now requires teams of specialists to undertake what Stan attempted alone. His vision was just a little ahead of his time.

Among his other publications were papers on the variation and zoogeography of Fiji frogs, on the amphibians and reptiles of his native Browns Flat, a popular booklet on amphibians and reptiles in New Brunswick and a more detailed treatment of those of the Quoddy Region (the latter with J. S. Bleakney), the "salamander" entry for the *Canadian Encyclopedia*, and even contributions on bats, the Short-nosed Sturgeon, and the origin of the Falkland Islands "wolf". One of his special interests was the distribution of the Gray Treefrog in New Brunswick and his last project was an intensive field search for it along the Maine-New Brunswick border. Stan was convinced that there were treefrogs to be found in western New Brunswick but it was not until the year after his death that his family proved him right, and several years more before others finally expanded the known distribution even more. Stan was also certain that the Northern Water Snake, *Nerodia s. sipedon*, would be added to the New Brunswick fauna from this region, but to date this challenge still remains unsatisfied.

Stan exchanged specimens with institutions all over the world. He was a scientific fellow of the Zoological Society of London for twenty-five years. His collections greatly enriched the holdings of both the Canadian Museum of Nature and the New Brunswick Museum. When he came back to New Brunswick he set to work immediately to reorganize the Museum collections to be research orientated and was responsible himself for the strong nucleus of mammal, amphibian, reptile, and fish reference collections. He was a member of the National Task Force on Ichthyology and Herpetology which attempted to establish national standards of data acquisition to be used in that part of the Cultural Heritage Inventory which involves scientific specimens.

Stan married Irenie Turnbull Whitehouse on 5 July 1943. Renie was his mainstay through all the good times and bad, always encouraging and organizing, typing and proofreading his manuscripts and voluminous correspondence. They raised a family of six children as close and supportive as they were themselves: David, born 21 March 1946 (commercial fisherman); Della, 19 May 1948 (school teacher); Jonathan, 21 January 1950 (Baptist Minister); Jean, 1 March 1952 (homemaker, former airline stewardess); Heather, 16 April 1957 (nurse); and Kent, 30 March 1964 (student).

Acknowledgments

I am deeply indebted to Irenie Gorham for reading and correcting earlier versions and contributing additional material, I am also grateful to Don McAlpine, New Brunswick Museum, and J. Sherman Bleakney, Acadia University, who also made substantial additions and corrections; and to John Gilhen, Barry Wright, Fred Scott, Nova Scotia Museum; E. J. Crossman, Royal Ontario Museum; Mike Rankin, Henri Ouellet, Earl Godfrey, Stu Macdonald, E. L. Bousfield, C. G. Gruchy, now or at that time at National Museum of Canada (now Canadian Museum of Nature), and Fred and Aleta Schueler, for correcting and commenting on an earlier draft. I have also referred to two accounts which captured the spirit of Stan Gorham for better by his friend Harvey McLeod: "Portrait of a Curator: The N. B. Museum's Stan Gorham" in *The Atlantic Advocate*, January 1981, pages 14 -17, written when Stan was still at the New Brunswick Museum; and the particularly moving "Remembering Stan Gorham" in *The Telegraph-Journal*, Saint John, New Brunswick, 4 August 1984, written after he had died. A more formal obituary, "Former Museum Curator Dies" appeared in *The Evening Times-Globe*, Saint John, 26 March 1984 (page 14). An earlier, uncorrected draft ("Stanley W. Gorham"), of my tribute appeared in the N. B. Naturalist 13 (2): 49-52 (1984). I am indebted to my colleague Don E. McAllister for providing an informal photograph of Stan from his own files.

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Book Reviews

Zoology

A Field Guide to Freshwater Fishes: North America North of Mexico

By Lawrence M. Page and Brooks M. Burr. 1991. The Peterson Field Guide Series 42, Houghton Mifflin Company, Boston. xii + 432 pp., 48 plates, 377 maps. U.S. $15.95.

This long-awaited guide complements those on Pacific (1983) and Atlantic (1986) coast fishes of North America. It briefly distinguishes, figures, and maps 790 species found in freshwaters of the continental U.S.A. and Canada.

The layout will be familiar to all users of Peterson guides. Short sections cover for each species "Identification", "Range", "Habitat", "Similar Species", and occasionally "Remarks". There are some text illustrations of identification characters but most species are illustrated in the 48 plates, 33 in colour, in the centre of the guide. Distribution is covered by the 377 maps grouped at the end of the guide. Some maps have the distribution of more than one species depicted on them. Information on a single species is therefore spread among three, widely separated parts of the book, an inevitable, but financially necessary, nuisance as in most field guides. While text and plates are indexed, maps are not requiring a double step to find a species map from the index via the text account. Colour is generally good as are pigmentation patterns in the black and white plates but with up to 22 species per 11 x 8 cm page, some detail and accuracy are lost. Maps run up to 6 on a page and vary in scope between all of North America to a single state. Some Canadian distributions are necessarily generalised to the point of inaccuracy.

North American freshwater fish families are all recognisable at a glance, with a little practice. The problem lies in the diversity within families. For example, minnows comprise 230 species and one genus alone, *Notropis*, has 71 species (there are 14 plates of minnow species illustrated and the text covers almost a third of the guide). The authors have tried to overcome this diversity by giving brief generic descriptions, thus chopping the family into smaller chunks, but considerable experience would be needed to identify minnows. It is tempting to suggest other or additional methods of grouping species, such as unique characters, comparative tables of characters, abbreviate keys, distribution, etc. but there is no real solution in the field guide format on a North American scale. Canadians would argue for a Canadian field guide since much of the diversity is found in the central and southern United States.

The guide incorporates a variety of recent taxonomic changes in the salmon, minnow, and catfish families not found in other recent books. This may cause some confusion to readers since the changes are not indicated and no reference source is given. The American Fisheries Society *List of Common and Scientific Names* (1991 edition) had not appeared when this guide went to press.

In a work of this scope errors in detail are unavoidable. The Atlantic (or Acadian) Whitefish, unique to Nova Scotia, is said to occur in "Leipsigate" Lake, correctly Milipsigate. Black Buffalo occur in Canada and Black Bullheads are found in British Columbia and Ontario but these distributions are not mentioned here. There are numerous other minor errors which, however, do not detract from the general utility of the work on a North American scale. Finally, freshwater fishes can attain a status in common with other taxa in the popular appreciation of natural diversity.

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A Field Guide to Western Birds

By Roger Tory Peterson, with maps by Virginia Marie Peterson. 1990. The Peterson Field Guide Series. Houghton Mifflin Company, Boston. (Canadian Distributor: Thomas Allen & Son, Markham). 432 pp., illus. Cloth $29.95; paper $19.95.

A new edition of a major bird guide is always an event. A new edition of one of Roger Tory Peterson's Guides is a red-letter event, keenly anticipated and eagerly welcomed when it appears.

This is particularly so in the case of the new Western Guide. Its predecessor predated all the contemporary advances in guides and bird identification, and it was never as satisfying a book to work with as the legendary Eastern Guide of the same vintage — the images were too small and the plates too cluttered. The current edition of the Eastern Guide appeared in 1980; since then the revised Western Guide has been awaited impatiently. It was worth the wait.

The new volume invites comparison on three levels. On the first, with its predecessor, this volume is vastly superior in virtually every respect. The more telling comparisons must be with the current Eastern Guide and with the book that has become many expert birder's guide of choice, the National Geographic *Field Guide to the Birds of North America* (NGG).

The reception of the earlier revised Eastern Guide was mixed: praise for the improvements, regret at the disappearance of some cherished features, and criticism because it did not incorporate some of the more esoteric advances in identification and plumage variations covered in the NGG. While some of this was legitimate, it also missed the point. The book's target is the beginner, not the aficionado; and anyone who has tried to help a beginner sort out the eccentricities of the admittedly fine NGG turns to Peterson with a sigh of relief.

Peterson's genius — I don't think the word is an overstatement — lies in making the bird on the page really look like the living bird. For the neophyte, having trouble separating thrashers from thrushes and thrushes from waterthrushes, that is the key to a successful guide. And that essential ingredient is all too often missing in the NGG.

But it's true, of course, that Peterson did sacrifice something in the process of simplification; and I, for one, wish there were fewer places where it was necessary to explain to the student that, well, "not all of them look like that". So the question in everyone's mind was how he would approach these problems in the new Western Guide. Now we have the answer: he has succeeded very well indeed. Compare the 1 3/4-inch Sanderlings in the Eastern Guide (no immature plumage at all) to the 2 1/2-inch ones in the new book — complete with immature! Look at the innovations such as the full page illustrating the plumage transitions of a 4-year gull (the Western).

In format the book follows the pattern of its eastern predecessor. The range maps are again at the back; a much-criticised element, but for me an eminently sensible trade-off to keep the key identification material as compact as possible, and avoid the minuscule maps of competing guides. These you can really see! They again appear to be accurate and surprisingly up-to-date. The rest of the book is also a delight, with large, clear images, sometimes — Rock Wren is a good example — showing different postures; and concise, informative text. Where relevant additional plumages are pictured showing local races, and there several pages of Mexican and Asian strays, replacing the Hawaiian species covered in the 1961 edition.

There are some flaws; for example, the paler lower mandible of the Great Crested Flycatcher is mentioned in the text (as "golden"), but missing on the plate (ironically, in the NGG the reverse is true!): and no undertaking of this magnitude could hope to satisfy every need. I wish a breeding plumaged Greater Yellowlegs was illustrated, and first spring Black-crowned Night-Herons are another source of confusion. The aficionados will still turn to the NGG for its extensive illustrations of plumage variations and for coverage of some finer points Peterson omits.

But quibbles are for book reviewers: this book is a tour de force, my reaction on finishing my first run-through was one of astonishment — How does Dr. Peterson continue to do it? Most of the other guides on the market are cooperative efforts! This book should be a delight to use in the field and, I suspect, become the guide of first reference for beginner and veteran alike. For easterners it's a good investment for its excellent shorebird and hawk plates alone. Get it.

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Mammals of the Neotropics, Volume 1: The Northern Neotropics: Panama, Colombia, Venezuela, Guyana, Suriname, French Guiana

By John F. Eisenberg. 1989. The University of Chicago Press, Chicago. x + 449 pp., illus. Cloth U.S. $85; paper U.S. $34.95.

The main thrust of this book is the synthesis of descriptions and distributions of the different mammals found in the arbitrarily defined northern Neotropics. Although there is a very fine reference for the mammals of North America south to Panama and including the Caribbean islands (Hall 1981), comparable information on South America is scattered, dated, and not as comprehensive. With increasing worldwide awareness of the effects of the continuing loss of tropical rainforest, there is a need to bring together our biological knowledge of all living organisms including mammals. Such information will benefit scientists, public officials, conservationists, and other interest groups in better understanding the complexities of the tropical ecosystem. This first of three volumes is taking us in the right direction though has fallen a bit short of my expectations, which probably were admittedly unrealistic considering the task at hand.

The bulk of the book deals with species accounts of mammals in the defined countries. These accounts are sandwiched between an introductory chapter on historical biogeography and contemporary habitats, and the final two chapters on speciation and faunal affinities, and community ecology. There are also 14 colour and seven black-and-white plates by Fiona Reid.

The approximately 400 species accounts are presented taxonomically and organized into 13 chapters representing the different mammalian orders found in the region. Generally, within each order, families are discussed and in turn are then divided into genera. Each of these successively more inclusive levels of classification are explained in terms of diagnosis, distribution, and natural history. The accounts themselves include description, distribution, range and habitat, and natural history for each species. This information is augmented by tables of measurements, line drawings, and systematic comments when deemed necessary. All species appear to have corresponding distribution maps. By and large, there are identification keys to the families and genera based on visible external features; however, there is no key to the orders and not all species groups have a key. Each chapter also has a separate bibliography that is quite extensive and relatively current. The plates include examples of all but three of the more poorly represented orders. They are of high quality with much detail, particularly, diagnostic features which facilitate identification.

According to the author, the book was intended as "an encyclopedia book for specialists as well as a practical volume for graduate students". The specialist may become frustrated, not because of incomplete knowledge but because of a lack of indepth detail. Eisenberg's strength is behaviour and ecology. This information and his citations are good, however, the systematic aspect is not on a par (i.e., the systematics of *Carollia* in South America is not as straightforward as one is led to believe). Naturalists may find their interests more satisfied with a relatively good field key, useful plates, and practical information.

As usual with a publication of this magnitude errors have crept in (i.e., the key to the species of *Micronycteris* does not correspond to the species accounts in the text). As a reference source, the reader is left with a feeling of incompleteness. Distribution maps rely heavily on shading as opposed to dots which would represent actual specimens examined, and there are several species with large question marks where their range is an uncertainty. This, however, does inform mammalogists of the areas that require future attention (i.e., mammals of Guyana and French Guiana are the least investigated in the study area). Identification keys based on other characters, such as cranial, should have been incorporated when there was no practical field key available. Even these deficiencies do not outweigh the usefulness and wealth of information compiled in this book.

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Alaska Whales and Whaling

By Alaska Geographic. First published 1978, fourth reprint 1989. Alaska Northwest Publishing (GTE Discovery, Bothell, Washington). $25.35 Canadian.

Alaska Whales is a special reprint of a more-than-10 year-old edition of the magazine, *Alaska Geographic*. As such, it is a series of articles rather than a coordinated book. About 40% is taken up by a field guide-like section on the fourteen species of great whale that frequent Alaskan waters. There are three short chapters on whale watching and whale biology. The remaining chapters are on whaling and its history. Each article is illustrated with plenty of fine photographs, both old and new, plus a number of black-and-white drawings.

Despite its age the articles make interesting reading. Do not expect anything controversial or emotional, nor any update on today's issues (results of the Exxon Valdez spill, for example). Although it deals with subsistence whaling in two chapters; one on early native techniques and one on modern methods; there is little in-depth discussion. There are potent arguments both for and against native subsistence (or "cultural") whaling and an exploration of these would have been most informative and inspiring.

The historical sections are told in a competent but rather dry style. Many other books I have read have given a much better sense of the excitement, the cold and hardships, the smell, and the enormous sense of destruction. The text, along with the photographs, is intriguing to read though, especially for the comparison one can make to whaling in other areas.

The section on the species of whales is the best part of the reprint. Organized in a field guide-like format, it gives a good summary of each species biology plus some anecdotes of whale behaviour. There is a range map covering the seas around the north-west coast of North America from Yukon to

Washington, plus the extreme north-east of Russia. In the brief species account there are instructions on how to identify the whales which are coordinated with the photographs. The field characteristics given are good and would work well in the field. However the description of Cuvier's Beaked Whale (or Goose-beaked whale) is very short and glosses over the key characteristic of this distinctive whale. The Minke Whale section is also very short; rather odd for a widely distributed and easily seen animal.

I was also surprised by the use of the word "Eskimo". Are the people of Alaska unaware that our northern peoples prefer to be called by their own term, Inuit?

Perhaps I have asked too much from what is really a collection of essays in a magazine. It would be better to simply enjoy the tales and the remarkable photographs of the worlds largest and most impressive animals.

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Advances in Herpetology and Evolutionary Biology: Essays in Honor of Ernest E. Williams

Edited by Anders G. J. Rhodin and Kenneth Miyata. 1983. Museum of Comparative Zoology, Cambridge, Massachusetts. xix + 725 pages.

Ernest Edward Williams was 77 in January 1991, and though he officially retired more than a decade ago, he is still a productive intellectual force associated with the largest preserved research collection of amphibians and reptiles in North America, that of the Museum of Comparative Zoology at Harvard University. Williams had been Curator of the herpetology collection since 1957 and was honoured at his retirement party in 1980 by former students and colleagues with the announcement of this tribute volume. It was published three years later.

A tribute volume shares with that of a symposium the virtue of being a collection from a variety of authors. Whereas a symposium collection usually probes only within a narrow portion of contemporary research, a tribute is generated by the lifetime influence of one person. Although the result could also be narrow, the present book is not. It is instead, a stew of interests, subjects, and organisms (most of them reptiles or amphibians), well reflecting the breadth of the man to whom it is dedicated.

The 50 individual papers are grouped into the broad sectional topics of Systematics (10), Comparative Morphology (12), Zoogeography (6), Ecology (11), Behaviour (3), Evolution (6), and Conservation (2). Contributions range from the description of a new plethodontid salamander from Guatemala and Mexico or the phylogenetic implications of the tarsus and metatarsus in *Protosuchus*, to an examination of the voluntary departure of lizards from very small islands or the reassessment of competition between *Anolis* and birds. And not all are herpetological, included is a discussion of two general problems involved in systematics and zoogeography of bats. Of course, the anoles are here. Williams lead an assault on anoline lizards with a multitude of students and colleagues over much of his career, using the group, particularly diverse in the West Indies (not an unattractive region in which to do intensive field studies), to collectively focus on comparative aspects of systematics, zoogeography, ecology, and behaviour within an evolutionary line. The anatomy of turtles is represented as well, a topic that Williams encompassed in his Ph.D. dissertation in 1949.

In all, there are 69 contributors to the volume (thumbnail sketches for each are presented on pages xi to xvi), a virtual who's who of herpetology, particularly for, but by no means restricted to, North America. They range through the alphabet from Angel Alcala to Suh Yung Yang, and include even a few Canadians such as Tom Parsons of the University of Toronto and a transitory Canadian, Franklin D. Ross, now settled into assisting the curation of the herpetology collections at the Museum of Comparative Zoology.

Its diversity makes this fat book impossible to shelve by any other topic save E. E. Williams, and that is just the point of it.

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Lizard Ecology: Studies of a Model Organism

Edited by Raymond B. Huey, Eric R. Pianka, and Thomas W. Shoener. 1983. Harvard University Press, Cambridge, Massachusetts. iv + 501 pp.

A symposium serves to consolidate information, bringing together specialists in various aspects of a limited topic for formal presentations and frank discussion and exchange of views and approaches. If publication funding exists, and contributors will produce written versions for editors, a hard-copy "state of the art" update results. These have the salutary effect of focusing attention on a field as important and dynamic at the moment and are a stimulus not just to contributors but as an entry, perhaps even an enticement, for those who will subsequently take up that research field. No less important, they are historical documents, time capsules revealing where research and theory was positioned at a given point, and thus long outliving their transitory stimulus at publication.

Lizard Ecology is the result of a December 1980 symposium held at the annual meetings of the American Society of Zoologists. It is second generation, following the example of an earlier volume, in 1967, simply titled *Lizard Ecology: A Symposium*, edited by W. W. Milstead (University of Missouri Press, Columbia). The present collection is divided into three major parts. Physiological Ecology has an overview by W. R. Dawson and presentations by A. L. Bennett; K. A. Nagy; W. P. Porter and C. R. Tracy; and J. J. Schall. Behavioral Ecology has an overview by R. Ruibal and contributions by P. J. Regal; C. A. Simon; G. W. Ferguson, J. L. Hughes and K. L. Brown; S. F. Fox; J. A. Stamps; and D. Crews, J. E. Gustafson, and R. R. Tolarz. Population and Community Ecology has an overview by T. W. Schoener and contributions by B. E. Ballinger; A. E. Dunham; R. B. Huey and E. R. Pianka; S. L. Pimm; T. J. Case; E. E. Williams; and J. Roughgarden, D. Heckel, and E. R. Fuentes. There is an introduction to the volume by the editors which summaries the contents and an ending Conclusion: Lizard Ecology Viewed at a Short Distance by P. R. Grant. Terminating the volume are 66 pages of References, 5 pages of Acknowledgement (both subdivided by individual chapters), a List of Contributors and their addresses and a 7-page Index.

The papers are variously complex, formula encrusted, and technical. They range from broad overviews of lizard ecological space and variation to those narrowly focused on a single species at a single place. The central theme is indicated in the book's subtitle; lizards are "low-energy" animals which provide a contrasting but abundant and successful model in ecological strategies to that of the "high-energy" birds and mammals. However, despite the repeated generalization of what "lizards" do, the actual number of really intensively studied forms is quite narrow. The bulk of the individual studies here are of diurnal and active "hot" iguanids like *Uta* of the American southwest and *Anolis* in the Caribbean and the teiid *Cnemidophorus*, again in the southwestern U.S. A much wider selection of the 3000 lizard species described for the world is needed for a broader synthesis.

Canadian readers will find few references to studies of any of our five species of lizards, none to Canadian populations, imbedded in the broad cross-lizard comparisons as summary data gleaned from earlier studies. Even these include only two of our three skinks (*Eumeces*) and the horned lizard (*Phrynosoma*). There are no referenced studies of the Alligator Lizard *Elgaria*. Despite the sophistication of some analysis, "the lizard" has yet untapped potential, particularly in northern habitats where low populations will pose even greater challenges in study time and design. This book provides indispensable models of field study and data analysis for future lizard investigations.

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Bird Flight

By Robert Burton. 1990. Facts on File, New York. 160 pp., illus. $31.95 in Canada.

Birds are surely the most attractive of all animal groups and the present book is a handsome addition to the large literature devoted to them. The author, well known as a zoological popularizer, provides in five chapters a detailed yet highly palatable treatment of flight as the central feature of birds. The first deals with the conquest of the air, including avian paleontology and the development of aerodynamics in both physics and ornithology. The second chapter examines birds as flying machines, including adaptations for flight, especially anatomical specializations such as the alula ("thumb") and tail, physiological modifications such as fat as a rich energy source, mechanics of flapping and issues related to speed, and feather care and moulting. Of particular note is that the problems of lift and propulsion, solved separately in airplanes, are both overcome by the complex wings of birds.

The next two chapters focus on skill and style in flight, such as take off, landing, control in social groups, and types of flight. The array of comparative material here on flapping, bounding, and soaring is impressive. The final chapter reviews life in the air in terms of feeding, avoiding predators, defending nests, migrating, breeding, and the ontogeny of flight. Indices and recommended readings are also included.

The text achieves a good balance between aerodynamic and zoological aspects of flight, and, characteristic of this publisher, is glossily illustrated with appropriate graphs, diagrams, and particularly photographs. The approach is pleasingly historical by including discussion of the contributions of early workers such as DaVinci and Borelli, and seasoned with tidbits such as the magical reputation of wishbones. Attention is paid to taxonomic diversity, topics of functional morphology such as optimization of performance, and conceptual issues such as the arboreal versus cursorial theories on the origin of flight, and why there are no viviparous birds. Overall this is an excellent work for anyone interested in birds or animal locomotion.

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Analysis of Wildlife Radio-Tracking Data

By Gary C. White and Robert A. Garrott. 1990. Academic Press, New York. xiii + 383 pp., illus. U.S. $59.95.

Radio-tracking has now been widely used as a technique to study wildlife. However, a reference containing all available analyses procedures for radio-tracking data had been previously lacking (*see review of* R. Kenward. 1987. Wildlife Radio Tagging: Equipment, Field Techniques, and Data Analysis; *Canadian Field-Naturalist* 105: 331). The objective of this book was to compile all available radio-tracking data analyses procedures. The authors expect potential readers to have at least a basic understanding of statistics and algebra.

This book starts with a list of available computer programs for radio-tracking data analyses. The SAS computer program is recommended. A recent computer program for analysing radio-tracking data became available after this book went to press (R. Kenward. 1990. Ranges IV. Institute of Terrestrial Ecology, Wareham, UK).

White and Garrott divided radio-tracking studies into three categories: descriptive, correlational, and manipulative. The authors emphasize avoiding descriptive radio-tracking studies. This suggestion, although currently popular, is questionable because descriptive studies often generate hypotheses for correlational and manipulative studies (*see* P. Martin and P. Bateson. 1988. Measuring behaviour. Cambridge University Press, New York). Moreover only basic descriptive studies may be feasible on threatened and endangered species.

As ultimately most radio-tracking data are analysed statistically, the authors suggest that one should obtain a random sample of individuals from a population and, if a small number of individuals are to be studied, only monitor members of same age-sex class. The authors also furnish formulas for estimating minimum sample sizes required for statistical analysis of radio-tracking data.

Radio-tracking studies generally assume that radio tags have little impact on the behaviour of study animals. White and Garrott, however, correctly stress the need to test this assumption, when possible, in all radio-tracking studies. The authors make five recommendations for researchers planning to radio-track: use the smallest transmitters possible, use cryptically-coloured transmitter packages, test transmitter mounting technique on captive individuals, allow a few days for animals to acclimate to transmitters before starting data collection, and avoid tagging animals during the reproductive cycle.

Testing the precision of radio-locations is dealt with in two chapters. White and Garrott present data analysis techniques for animal movements, home

range sizes, survival rates, and population estimates. Most analysis techniques are exemplified. Computer programs for analysing these data are presented in nine appendices.

The chapters of this book are logically sequenced. Each chapter has a helpful point-wise summary of main points. The text is easy to read and amply supported by tables and figures. My overall impression of White and Garrott's effort is good. This book will be an important source for students and professionals interested in radio-tracking.

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Parrots: A Natural History

By John Sparks and Tony Soper. 1990. Facts On File, New York. 240 pp., illus. U.S. $24.95; $31.95 in Canada.

Do you think of parrots as gaudy clowns? Do you think the biology of birds is a dry scientific topic? Then this book should make you think again. Parrot personalities are as lively and bright as their colours. And the authors have made this one of the most readable, yet scientifically accurate books on avian biology. I could find only one howling mistake. The authors include Hudsonian Godwit in a list of extinct birds!

Parrots are, without doubt, one of the brightest groups of birds on earth. How do they get such magnificent colours? The authors' explanation is easy to follow and I have no difficulty in deducing why budgies are either green, blue, yellow, or white.

Parrots come in astonishing range of sizes too, and yet all species bear a superficial resemblance to each other. Although there is not the obvious range of differences as, for example between finches and woodpeckers, parrots do have specialist adaptations. Much like Darwin's finches, there are "woodpecker" parrots with stiffened tails, motmot-like parrots with raquet tails and long-billed birds adapted for digging. Another, more hidden part of the anatomy, the parrot's tongue is a remarkable structure but the range of types of tongue is even more remarkable. Some are powerful enough to hold a rock-hard nut steady while the vice-like bill is used to split it open. Other tongues are long, delicate, and end in a brush-like tip that is an efficient nectar sponge.

Some years ago I mused that the plainest birds had the best songs while the most colourful had voices bordering on the unpleasant. I found many examples to support this theory but, alas, there were many that did not. Parrots are a group that fit this theory. Many of us have had our un-caffeinated, early morning nerves jolted into reality by the greeting shrieks of the family budgie. All parrots it seems can assault the eardrums and their wild cries are often what alerts us to their presence. But parrots are great mimics and can be trained to imitate much softer sounds, including human speech.

No natural history book today can sadly escape dealing with the decline of its own subject. Parrots as a group are particularly hard hit. They live in forests that are being destroyed for lumber or to provide farmland. Many eat fruit, nuts and grain, making them pests to be exterminated. They are colourful, cheerful, long-lived, and adaptable and therefore make excellent pets. Parrots fetch such high prices and profits that smuggling is a serious menace. All of these factors have meant trouble for the parrot family. Additionally cats, rats, goats, and pigs have spelled trouble for island birds.

Parrots are typically good parents. Under their original conditions there was little need for high productivity. As these birds can live 10 to 70 or more years this slow birth rate was in harmony with their environment. As forest conditions have deteriorated this policy of carefully nurturing a few well-trained offspring is a disaster.

This gives you some idea of what this book contains. I would recommend it not only as a book on parrots but as a readable background to bird biology in general. The author's style is as easy to read as Agatha Christie and the basics are common to all birds.

The book is illustrated with coloured photographs and black-and-white line drawings. All are of good quality. Most of the drawings are by Robert Gillmor, an experienced and respected British artist. There are a few illustrations, both whimsical and serious, by the humourist Edward Lear. Although Lear is best known for his nonsensical poems, he started life as a bird illustrator and his serious work is magnificent.

A last word, at the author's suggestion there is something we can all do for parrots. Never, never buy one. That is unless you are completely certain that it was reared in captivity. The laws to protect wild parrots are not working well, and the ultimate control lies with us, the potential customers. North Americans, Europeans and Japanese are the major consumers. By simply saying "No" whenever the bird's origin is in doubt we can all help reduce the toll on these fascinating creatures.

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Étude et aménagement de la frayère multispécifique de la rivière aux Pins et dynamique de la population de Grand Brochet, *Esox lucius* L., du fleuve Saint-Laurent, Boucherville, Québec

Par Gérard Massé, Réjean Fortin, Pierre Dumont et Jocelyne Ferraris. 1988. Rapport technique du Ministère du Loisir, de la Chasse et de la Pêche no. 06-40, Gouvernement du Québec, Montréal. XXVII + 224 pp., 64 figs. Gratuit.

Cette étude se fixait les trois objectifs suivants: caractériser l'utilisation temporelle (i.e.: montaison et avalaison) des différentes espèces de poissons qui se servent de la rivière aux Pins comme frayère, par rapport à un ensemble de variables environnementables (i.e.: températures, durée d'ensoleillement, précipitation et niveau d'eau); évaluer divers paramètres de la dynamique de population (i.e.: croissance, mortalité, déplacements dans le fleuve Saint-Laurent et variations de la force des classes d'âge) du Grand Brochet et; déterminer la pertinence de contrôler le niveau de l'eau sur la frayère pour favoriser le succès de reproduction de cette espèce. L'étude est très détaillée et les objectifs ont bel et bien été atteint.

Au moins 16 des 44 espèces recensées à la rivière aux Pins y frayent. Douze espèces sont décrites en détail quant à la montaison et l'avalaison. Il s'agit du Grand Brochet, de la Perchaude, de la Barbotte Brune, du Crapet-Soleil, de la Marigane Noire, du Meunier Noir, du Poisson-Castor, de la Carpe, de l'Achigan à Grande Bouche, du Crapet de Roche, de la Lotte et de l'Anguille d'Amérique. La période de fraye a pu être déterminée pour les neuf premières espèces citées.

Les figures et photographies n'apparaissent pas dans l'ordre qu'elles sont présentées dans le texte de sorte que le lecteur doit effectuer un va et vient continuel. De plus, la légende de la photo 11 renvoye à la photo 15 mais elle devrait plutôt renvoyer à la photo 17. De même, celle de la photo 17 renvoye à la photo 9 mais elle devrait renvoyer à la photo 11. La figure 6 est tirée de Massé (1981), mais cet ouvrage ne figure pas dans la liste des références. Bien que les auteurs comparent leurs résultats sur les grands brochets avec ceux de plusieurs études, ils ont omis l'étude de Mongeau (1976) qui elle aussi a parue comme publication du gouvernement du Québec. Les auteurs employent les acronymes PSD et RSD pour des paramètres qu'ils ne définissent pas dans le texte bien qu'ils renvoyent le lecteur à des articles sources. Il s'avère que ces acronymes désignent respectivement le "Proportional Stock Density" et le "Relative Stock Density" et que ceux-ci sont expliqués dans Fournier *et al.* (1987). Le texte est abondamment illustré de figures et de photographies de qualité supérieure.

Il est louable que Massé et ses collaborateurs aient favorisé une approche de gestion globale, en tenant compte des exigences biologiques d'autres espèces de poissons en plus du Grand Brochet, l'espèce visée principalement. Voilà le type de gestion et d'aménagement souhaité. Il est essentiel de protéger des milieux servant de frayère et de nurserie multispécifique tel la rivière aux Pins, et ce point n'a pas été soulevé. Cet ouvrage est très important pour les gestionnaires des pêcheries dulcaquicoles et les biologistes s'intéressant au milieu aquatique car les résultats dans ce rapport peuvent s'appliquer à d'autres régions du Canada et des Etats-Unis.

Literature Cité

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An Annotated List of the Birds of Bolivia

By J. V. Remsen, Jr. and Melvin A. Traylor, Jr. 1989. Buteo Books, Vermillion, South Dakota. 79 pp. U.S. $15.

This is principally a distributional checklist of the 1274 species of birds recorded in Bolivia. The authors suggest that at least 150 more species will eventually be added to the list of birds of this land-locked South American country. The nine departamentos of Bolivia have a tremendous variety of habitats from lowland Amazonian rainforest to snow-covered mountain tops, in an area of just over one million square kilometres.

The authors give a complete list of species recorded in Bolivia, and for each of its nine departamentos, together with an indication of the life zone(s) in which they occur. For a species' occurrence in each departamento they give a literature citation. This must have required a phenomenal amount of "homework"!

They point out that many birds shown in other range descriptions as occurring in Bolivia lack documentation. In particular, they make many comments about *Aves de Bolivia* by Noel Kempff Mercado, 1985, Editorial Gisbert, La Paz. That very attractive little book has many good colour photographs and line drawings which the current book lacks. However, it lists 62 species for which the present authors say no valid record for Bolivia has been published. Some may have been recorded by Kempff himself, but "The details were not published before his unfortunate and untimely death".

Remsen and Traylor have produced a valuable scientific work, using impeccable standards. They point out where more field work should now be done in this comparatively unstudied country, with its huge expanses of unmodified habitat. This little book would be most useful to anyone planning a birding trip to Bolivia.

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Bear-People Conflicts: Proceedings of a Symposium on Management Strategies

Edited by Marianne Bromley. 1989. Proceedings of a conference, Yellowknife, 6-10 April 1987. Northwest Territories Department of Renewable Resources, Yellowknife. 246 pp., illus. $25.00

The problem of bear-people conflicts has intensified in recent years, primarily due to increased human expansion into bear habitat. The need for collaboration on policy and techniques to improve these relationships has become apparent. This long-awaited symposium brought together experts primarily from North America to discuss problems and solutions regarding bear-people interactions. Symposium co-chairmen Paul A. Gray and Peter L. Clarkson state, "This symposium was designed to facilitate the exchange of information about bear-people conflict management now being applied, designed, and/or tested". I believe that this objective was met.

The proceedings contain 34 papers or abstracts of an array of topics that have been characterized under four more general headings; (1) behavior and ecology of problem bears, (2) bear detection and deterrent techniques, (3) problem bear management programs, and (4) bear conflicts: public education and the media.

Section 1 contains eight papers discussing behavioral plasticity, the role of learning, movements in relation to human activity, and associations between bears and human foods, including garbage dumps. Section 2 has six manuscripts including the use of dogs, firearms, and fences as deterrent systems. Gray and Sutherland provide a thorough overview of the history and current developments of bear detection/deterrent systems, stating the advantages and disadvantages of each. Section 3 includes 18 contributions providing overviews of current management practices and activities developed by various provincial, state, and federal agencies. Section 4 contains two articles addressing the need for, and techniques used to, properly educate and create a well-informed public.

In addition, two panel discussions on interjurisdictional problem bear management and the future direction of problem bear research and management are summarized. Two workshops discussing problem bear management policy and planning and deterring, capturing, and handling problem bears are included. F. L. Bunnell acted as rapporteur, admirably summarizing symposium highlights and reemphasizing areas requiring additional research.

As with most proceedings, writing style and quality of manuscript content varied widely between individual papers. The only serious error was the omission of pages 147 and 148, which greatly reduced the usefulness of one paper. Aside from this error, Marianne Bromley did an outstanding job as editor, maintaining a consistent format with an attractive layout design. The text is highly readable and contains few typographical errors.

A wealth of well-documented examples on bear biology and behavior as related to humans, and management strategies used to improve human-bear sympatric relationships was presented. I believe the next step is to synthesize results from this proceedings and other available information in an attempt to predict the outcomes of future potential human-bear interactions. This synthesis would likely reveal additional management strategies, promoting improved coexistence.

I concur with symposium co-chairmen that future symposia of this nature be conducted every three to five years, providing an opportunity for research and management personnel to exchange information and present summarized findings in proceedings for distribution to other biologists and the public. I recommend this book to biologists working with *Ursus* spp. and any individuals frequenting bear country.

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A Field Guide to Reptiles and Amphibians: Eastern and Central North America

By Roger Conant and Joseph T. Collins. Third edition. 1991. Houghton Mifflin Company, Boston. Illustrated by Isabelle Hunt Conant and Tom R. Johnson. 450 pages, 48 color plates. Cloth $22.95; paper $15.95.

In its original 1958 edition, this was the first amphibian and reptile field guide in the Peterson series. Added to the format that Peterson had pioneered for birds in 1934 were maps for each species, long before these were adopted in revisions of the bird guides. The care and uniformity of its approach made it not just a handy reference for the professional but *the* primer for every subsequent fledgling herpetologist in eastern North America. In 1975 a revised edition, also by Roger Conant, added the species in central North America. In this, the third edition, Conant has been joined by Joseph T. Collins as junior author, and the text reworked to add newly described and some introduced species, updated taxonomy, and new biological information on many taxa.

The original plates were skillful photographs, many hand coloured before reproduction by Isabelle Hunt Conant. Her death created a potential vacuum for this revision. Tom R. Johnson, however, has taken up the technique and provided quality colour versions of all plates originally left black-and-white, as well as adding illustrations for newly included taxa. These are true to the sharpness of the originals and the only conspicuous difference is that they tend to be slightly more pastel in tones with blues appearing to be particularly emphasized in some species.

The maps have been redone, and here the evolution of the book, and of North American herpetology, is particularly apparent in the greatly enhanced precision now possible for many areas, particularly in the United States. The Canadian portions generally follow Cook (1984) but are updated from subsequent information. Three Canadians (W. B. Preston, M. J. Oldham and F. W. Schueler) are singled out for having contributed unpublished distribution data to this edition from their compilations in progress. The "pinking-shears" edge effect of many northern limits which is new to this edition, however, is likely not their responsibility. It apparently does not indicate a vast number of new records but seems to be artistic licence to simulate possible unevenness of northern limits. Mink Frog records in northern Quebec and Labrador are shown as two pockets isolated from the main body of the range, and the Labrador range of the Blue-spotted Salamander is depicted as discontinuous. Neither appear to be based on any new data nor on breaks in suitable habitat. While it is valid to thus highlight the paucity of northern records, the approach could equally have been applied to the northern distribution of many other species as well. For Newfoundland, which has no native species, only the Green and Leopard frogs are mentioned in the text as introduced; others, American Toads and Wood Frogs, are not; all are mapped without differentiation between natural and human-vectored occurrences. The Chorus Frog is not mapped for Newfoundland, an omission which follows the map in Cook (1984), although the text of the latter did mention its introduction. A problem here is doubt of its persistence, possibly due to interactions with Wood Frogs (*see* Maunder 1983).

The most disappointing addition is the half-hearted stab at tadpole identification (but none at salamander larvae) in which only 14 representative species are figured and described. Eight of these, however, occur in Canada.

Recent taxonomic innovations have been weighed and many accepted. *Trionyx spiniferus* becomes *Apalone spinifera* (following the revision by Meylan 1987; but even though widely adopted this shift it not without its critics; e.g., Walls 1991). The Painted Turtles are no longer lumped with the sliders so the genus *Chrysemys* once again contains only *C. picta* (*see* Seidel and Smith 1986). A return to the spelling given in original descriptions has changed *woodhousei* to *woodhousii* for Woodhouse's Toad (Fowler's Toad is its subspecies in Ontario), and *platyrhinos* to *platirhinos* for the Eastern Hognose Snake. But not all recent taxonomic changes have been adopted for this edition. Common Musk Turtle (formerly the Stinkpot) is retained in the genus *Sternotherus* rather than transferred to *Kinosternon* (*see* Seidel et al. 1986). The Boreal Chorus Frog remains a subspecies, *Pseudacris triseriata maculata*, instead of being elevated to species status (Platz 1989), though the latter may be only because the guide went to the printer before this proposal was published.

A decision to drop recognition for snake subspecies that had been delimited on geographic scale count differences means that the Western Green Snake, *Opheodrys vernalis blanchardi*, is gone from this edition, but subspecies defined on pattern differences are retained, even if they only show a distinctiveness mainly in their average dorsal blotch count, as in *Elaphe vulpina gloydi*. As any geographic variation could be an indicator of past isolation or reduced gene flow, it seems strange biology (though the concept here seems to be that it is good amateur herpetology; scale counts are laborious and have to be done with care) to eliminate some taxonomic entities that can not be quickly visually distinguished.

The biochemical analysis (Hedges 1986) leading to the transfer of Spring Peepers into the genus *Pseudacris* as *Pseudacris crucifer* has been possibly too eagerly accepted; chromosome data published subsequently (Anderson 1991) does not appear to

support this change. Perhaps the conservative approach that kept the authors from combining the garter and some water snakes together should have been applied here as well. A more radical approach, placing *Hyla crucifer* into a monotypic genus, *Parapseudacris* (Hardy and Borroughs 1986), has been ignored.

As in Stebbins' (1985) similarly classic western guide in the same series, my study (Cook 1983), that analyzed and mapped the continuous interbreeding throughout the contact zone between *Bufo americanus* and "*Bufo hemiophrys*", and concluded that these taxa are best combined as a single species, is ignored. This follows Green's (1982) electrophoretic analysis of clearly clinal allozyme variation along one transect through the hybrid zone which paralleled the morphological and call intergradation I had documented. Green's justification rested on the degree of distinctiveness of these taxa to either side of the hybrid zone and his tenacity to a species definition as "whatever I recognize as different", a fairly common stand in taxonomy. These toads in nature, however, apparently never recognize each other as different and interbreed freely wherever they meet, not just at occasional or a few disturbed (or new) contact points (as is the case with the clearly specifically distinct *Bufo a. americanus* and *B. woodhousii fowleri*). Arguably, only restriction to relatively infrequent interactions would clearly justify retention of distinct species status for each, but views on this are among the most contentious in current taxonomy. The authors' omission of noting or even mapping this well-documented hybrid zone poorly serves the user, whatever taxonomic arrangement is preferred. It is also partially inconsistent with some other all-contact clinally hybridizing taxa treated as subspecies with contact zones sometimes indicated. It is mentioned in the introduction to the toad section that:

> "To *complicate* matters, certain *species* are known to hybridize with others. This *unfortunate state of affairs* undoubtedly has been aggravated by the human propensity for altering habitats and thus bringing animals together that had remained isolated for one reason or another in prehistoric times" [italics added].

However, rather than being complicated or unfortunate, these population hybridizations are likely repeating events throughout rearrangement of distributions during successive continental glaciations, their intervening interglacial periods, and climatic shifts (though human habitat alteration may bring added opportunities now). They are a natural part of the dynamics of population relationships throughout time, not simply insignificant taxonomic inconveniences or abberations to be glossed over, even in field guides. This is particularly true for a guide which points with justifiable pride to the wide use of earlier editions in university-level courses.

There are other minor points that also should be especially noted by Canadian readers. Cook (1983) documented that northern *Bufo americanus* often have spots that coalesce and that this results in these encompassing numbers of warts. This edition, however, persists in the characterization of *B. americanus* as generally having few warts per spot in order to distinguish them from *Bufo woodhousii fowleri*. Although this holds well for *B. americanus* individuals within *B. w. fowleri* range, it fails north of it, and has lead in the past to mistaken identifications, particularly for juveniles, of *americanus* as *fowleri* and therefore creation of erroneous "range extensions" (*see* Green 1989 for examples). "*B. hemiophrys*", based on my experience with it across the Canadian prairies (Cook 1983), may not be nearly as characteristically aquatic in habitats as the older literature based on Minnesota populations indicated — yet only these earlier impressions are used. The retention of the text trinomial "*Bufo hemiophrys hemiophrys*" because of the subspecific status once given the disjunct Wyoming population (*B. h. baxteri*) also overlooks Cook (1983) which questioned the distinctiveness of this form. Inconsistently, *Rana sylvatica*, which also is mapped as having a "western subspecies" (though the validity of such has also been questioned by others), is given as a binomial in the text.

The accounts for Blue-spotted and Jefferson salamanders do not give separate species recognition for hybrid polyploid forms but omit mention of notations for these forms advocated by Cook and Gorham (1979) and more recently, on the basis of extensive studies, by Lowcock et al. (1987). Their collective distribution in the area co-occupied with one or the other of their diploid parental species is mapped, but the different combinations are not distinguished (a preliminary map which does show the distributions of different polyploids has been since published by "Lowcock" 1991). The equally interesting polyploid hybridization of the Smallmouth and Tiger salamanders with the Blue-spotted Salamander is barely mentioned, presumably because of its very limited geographic extent, largely in the Lake Erie "Put-in-Bay" archipelago in Ohio and Ontario which includes Pelee Island in the latter. The failure to attempt separate mapping for the two Gray Treefrogs, *Hyla versicolor* and *Hyla chrysoscelis*, is a disappointment even though one might anticipate that they could eventually come to be regarded only as ploidy variants of a single species. They are often clearly distinguishable by call in the field (based on Canadian observations in Manitoba by myself and K. W. Stewart), contrary to the impression given in the text.

In the introduction, the newest edition of common names (Collins 1990) is promoted as gaining wide usage. However true, these names are simply for the

convenience of English-speaking amateurs without the internationally accepted convention or usage that applies to scientific names. These English names change at the whim of committee composition and unsatisfactory choices should freely be amended with more logical or useful alternatives (*see* use in Cook (1984) of Midland Chorus Frog and Tetraploid and Diploid Gray Treefrogs).

In places, the third edition seems to talk down to the amateur (with expressions like, in reference to the generic shift of Spring Peepers, "*Professional* herpetologists, based on *laboratory techniques*, recently transferred..." [italics added]), something of which the first two editions were markedly free.

These irritations aside, this is a fine guide and no herpetologist's or naturalist's library can be without the newest edition. Good points and bad will serve as a standard for at least the next decade and a half, and also as a convenient base-line not just for identification but for the vast amount of research yet to be done on taxonomic relationships, distribution, and life history.

It is perhaps fortunate that the guide went to press before the recent radical taxonomic shifts recommended by the junior author (Collins 1991), although his subsequent publication is perhaps anticipated in remarks in the guide introduction on page 9. Collins (1991) elevates to full species status a large number of disjunct populations that have been at one time or another regarded by some herpetologists as differentiated from their main populations. Included in this wholesale shift are some taxa of Canadian interest: *Coluber constrictor mormon* would become *C. mormon*; *Plethodon vandykei idahoensis* = *P. idahoensis*; *Pituophis melanoleucus sayi* and *P. m. deserticola* = *P. catenifer sayi* and *P. c. deserticola*, respectively; *Elaphe vulpina gloydi* = *E. gloydi*. (Incidently, the questionable [Cook 1983] *Bufo hemiophrys baxteri* is upped to *B. baxteri*). Collins argues that ranking these taxa and many others as subspecies obscures the true diversity of the North American herpetofauna. Unfortunately, his solution would equally obscure important zoogeographic relationships. Worse, it appears to tailor taxonomy to a tool for enhanced justification (and funding ?) of conservation of disjunct populations and thus clearly undermines its credibility. Many of these shifts have been suggested and rejected before in the scientifically reviewed literature, some involve taxa that are regarded by some taxonomists as having tenuous validity even as subspecies, others may not be as clearly disjunct as is assumed.

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Significant Trade in Wildlife: A Review of Selected Species in CITES Appendix II. Volume 2: Reptiles and Invertebrates

Edited by Richard Luxmoore, Brian Groombridge, and Stephen Broad, IUCN Conservation Monitoring Centre. 1988. A joint publication of the International Union for Conservation of Nature and Natural Resources (IUCN), Gland, Switzerland and Cambridge, UK, and the Secretariat of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, Lausanne, Switzerland. Printed in Canada by the Canadian CITES Management Authority (Canadian Wildlife Service), Ottawa, Ontario. 308 pp. Available from CITES Secretariat, World Conservation Centre, CH-1196, Gland, Switzerland. 25 Swiss Francs.

In 1973 an international contribution to the regulation of the human utilization of wild animals and plants, and therefore to conservation around the world, was initiated by the drafting of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). This convention addressed a problem that had long been recognized as critical. No matter what effort countries put into attempting to control the decimation of natural populations within their borders, they would fail to stop illegal export as long as unrestricted import was allowed by those countries with affluent consumers.

CITES was a agreement among signatory countries that they would not allow exportation of animals or plants agreed to be endangered or potentially endangered by trade unless their import had been previously approved by their country of destination. The country issuing the export permit must be recognized by the international community as actively monitoring and regulating exploitation of its wildlife. Further, it should be keeping exploitation below that level which would reduce the contribution of a species to the natural ecosystems in which it occurred.

Two species lists were developed as appendices to the Convention. Appendix I contained animals and plants so rare that no commercial harvest could be reasonably allowed. These species could only be imported if they had both an export permit from the country of origin and an import permit from the country into which they were being imported. The double requirement allowed both countries to monitor and restrict the exchange of species or their parts to that between recognized scientific and educational institutions only, and thus prevent them from entering commercial trade. Appendix II contained animals and plants which had populations low enough that they could be at least potentially endangered by unregulated trade, but high enough that commercial trade could be allowed if the populations were being adequately managed. These could be imported with only an export permit from the country of origin — essentially an acknowledgment from that country that it knew these animals had been taken and felt that they were surplus to the survival of that form in their jurisdiction. This Appendix also contains species that can not be distinguished by appearance from species on Appendix I.

CITES has now been functional for over 15 years, 110 countries are signatory, and meetings of national representatives are held every two to three years. (In June 1987, a national meeting was held in Canada, in Ottawa). The Canadian Wildlife Service has provided the Canadian management and scientific authority groups since Canada signed in 1975, but there has also been active participation by other federal and provincial representatives and by scientists from other institutions, both governmental and non-governmental.

The printing of the second volume of *Significant Trade in Wildlife* is a part of Canada's contribution to the CITES process. This book provides analysis of the known biology and status of populations of selected species on Appendix II. Those covered were regarded in a preliminary assessment as having a significant volume of individuals in trade. Detailed species accounts are compiled for 36 Appendix II reptiles (7 turtles and tortoises; 3 crocodilians; 19 lizards; 7 snakes), 2 butterflies, 1 snail and 1 coral. None of these occur in Canada. Each account is headed by the common (English) name of the organism, its scientific name, describer, and date of first description, its order and family assignment, and a numerical evaluation (1 = potential problem; 2 = possible problem; 3 = no problem). The text leads off with Summary and Conclusions, and is followed by Distribution and Population (with separate subsections for each country for each section), Habitat and Ecology, Threats to Survival, International Trade (for the period 1980-1985, with summary tables), Conservation Measures (subdivided by country), Captive Breeding, and References.

The accounts are in English but there is a 5 to 7 page Introduction to the book in English, French, and Spanish. This outlines the problems faced by CITES in evaluating what Appendix II species were most of concern and the need to assist countries containing these species with evaluation of population levels and possibly acceptable harvest totals. The committees and stages of deliberation in the development of the list and the sources of data on which this publication is based are also discussed.

This book is a credit to everyone involved with its production but above all to the teams (identified in the initial acknowledgments page) which synthesized and evaluated the information it contains. It is an eye-opener to anyone not previously aware of the extent of consumptive commercial use of reptiles worldwide, and a sobering commentary on their future. It should serve to promote wise management, regulation and enforcement.

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Note: A complete current listing of all animals and plants on the CITES Appendices (Control List 9, 18 January 1991) and information and forms for permits is available from the: Administrator, Convention on International Trade in Endangered Species, Canadian Wildlife Service, Ottawa, Ontario K1A 0E7 (613-953-1411). Failure to have required import or export permits for any listed species alive or dead, or parts of listed species raw or manufactured, can result in customs seizure of specimens or goods without return. A complete list of CITES publications is available from the CITES Secretariat in Switzerland (see above).

Ontario Herpetofaunal Summary 1984

Compiled by Michael J. Oldham and Donald A. Sutherland. 1986. Essex Region Conservation Authority and World Wildlife Fund Canada. 214 pp.

Ontario Herpetofaunal Summary 1985

Edited by Michael J. Oldham. 1988. World Wildlife Fund Canada, Essex Region Conservation Authority, and Ontario Ministry of Natural Resources. 206 pp.

Ontario Herpetofaunal Summary 1986

Edited by Wayne F. Weller and Michael J. Oldham. 1988. Ontario Field Herpetologists, Cambridge, Ontario. 221 pp.

Ontario Herpetofaunal Summary 1986 Technical Supplement

Edited by Michael J. Oldham and Wayne F. Weller. 1989. Ontario Field Herpetologists, Cambridge, Ontario. 197 pp.

These four volumes are the output to date of an ambitious continuing project, one of whose objectives is to map the distributions of the 49 or 50 native species of amphibians and reptiles in Ontario. (Canada as a whole has only 84 to 86 native species depending on whether you lean to lumping or splitting.) Also included are two introduced species, the Red-eared Slider (*Pseudemys* [now *Trachemys*] *scripta*) and the Box Turtle (*Terrapene carolina*).

The Ontario Herpetofaunal Summary (OHS) was begun in 1984 with a call for the participation of observers throughout the province and a promise to produce an annual report listing and mapping all contributed records for that year. When the results of the 1984 surveys appeared in 1986 they assured the continued success of the project. Nothing enthuses observers and financial supporters like actually seeing, within a reasonable time, the results of their contributions. In subsequent years, observations have continued to pour in at an accelerating rate.

Although publication time has subsequently lagged, the scope of the project has become increasingly ambitious. The species accounts were expanded in the 1985 and 1986 volumes. What were, initially, only brief summaries of observations with locality lists and distribution maps have evolved into longer discussions with additional detail including histograms of seasonal observations. Changes in nomenclature have been noted and the reference sections have kept up with the literature current to the time of each publication.

The maps have also evolved with the volumes. Initially they were outlines showing counties and districts, one for southern Ontario and one for northern. Later, a grid of ten- kilometre squares was added to the southern Ontario maps to facilitate plotting with an early computer program and to stimulate greater coverage effort by challenging observers to fill in empty squares. With more sophisticated programs automated plotting will produce more precise gridless locations in future volumes.

In the initial year the introductory sections, all species accounts with summaries, locality lists, and maps, references and the list of contributors, could easily be accommodated in a single volume. By the third they required two, one of these for locality lists alone. As compilation time lengthened, it also became apparent that annual publication could not be achieved. The most recent instalment, nominally for 1986, has an added section of mapped records for all species up to and including data received through 1988, though the locality lists and analysis for 1987 and 1988 could not be included. It also has a section pointing out, species by species, areas in the expected ranges and/or at their edges where more concen-

trated work is badly needed. In the 1985 and 1986 summaries, species accounts were assigned to 29 individuals especially knowledgable or interested in particular species.

There are a few negative comments worth making. The histograms added in the recent summary, unfortunately, are more decorative than instructive and likely depict observer intensity better than amphibian or reptile activity. They lump adults and juveniles without discrimination. The number of observations, not numbers of individuals, are used and all Ontario data are pooled together as if the province was homogeneous in habitat and climate. The first edition did not distinguish records where museum specimens were available for verification from sight records, and later editions still often do not cite catalogue numbers. This seems trivial, but is not if a citation is to be verified in future. Without a catalogue number, an identification that is later changed at the museum can not be easily traced to its specimen. In one case where a museum is given, it is inaccurate because no check was made on whether a specimen was actually deposited where originators of the record first indicated it would be. Even though observers are noted for each record, we must trust solely the editors' screening for judgement on reliability under the conditions taken. On current maps all dots are the same regardless of whether they are documented (by specimens or photographs) or undocumented; for this information the text has to be searched. Listings of localities for 1986 have added a vagueness factor by giving indefinite descriptors and incomplete grid references in the technical supplement. The argument is that this protects the exact location of populations from unscrupulous collectors. It may, however, also keep those aware of impending development ignorant of the precise location of habitats that are important to defend, and will likely prevent workers at some future date from verifying the continued existence of populations. To counter that those who would use detailed information legitimately can contact the summary for them is to assume that they will make this added effort, that legitimate requests can be recognized, and that the Summary custodians will always respond from their full data intact forever. In the long term, the only assured availability for data is by full publication, and the long-term benefits of this may outweigh possible occasional short-term misuse. It is its policy of secretiveness and lack of emphasis on the importance of verification that removes the *Summary* from scientific literature and will detract from its usefulness as a primary reference for future monographic treatments of individual species ranges and detailed zoogeographical and ecological syntheses.

Oldham, Weller, Sutherland, their collaborators, and the legion of volunteer observers, are to be applauded for having boldly undertaken this task. That they poured so much of their own personal time into a project that will be useful to many conservationists, and be a starting base for tracking valid records for many other projects, despite its deficiencies, can not be overvalued. In the past decade, neither major museum in Ontario, their staffs and funding spread so thinly over other priorities, could possibly have undertaken such a labour-intensive, long-term endeavour no matter how badly it was needed. Both have, however, contributed to it. The Canadian Museum of Nature, with approximately 12 000 Ontario catalogued collections, whose staff and volunteers have contributed since 1985, will be an even greater source in the next stage when all pre-1984 collections, literature records and archival observations are added to the data base (perhaps even with appropriate catalogue numbers cited). Similarly, the Royal Ontario Museum has contributed recent records and will also be a primary source of historically valuable pre-1984 data.

The many financial supporters, the Ontario Ministry of Natural Resources, the Essex Region Conservation Authority, the World Wildlife Fund (Canada) and the Canadian Amphibian and Reptile Conservation Society, who have made the publications possible, are deserving of special note. One spin-off from the project already is the contribution of the most recent data (provided in advance of the next publications) for updating the series of Status Reports completed or in preparation for 21 species of amphibians and reptiles regarded as possibly at risk in their Ontario range by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

The *1986 Summary* includes an announcement of the formation of the Ontario Field Herpetologists to publish it and future volumes, a section analyzing the data base so far, and detailed instructions to observers. The next step for the *Summary* is the synthesis of all observations from 1984 to 1990 inclusive, and the inclusion of all pre-1984 records from field notes, published literature and museum collections both in Canada and in the United States. In 1984, 169 individuals contributed 2460 records; in 1985, over 300 individuals contributed 4534 records; in 1986, 586 participants contributed 6100 records. Current estimates are that total records will be at least 60 000 when observations to the end of 1990 are combined with the pre-1984 archival records still being compiled. Due to the steady increase in data, future volumes will treat groups individually, the first in late 1992 on turtles and the one lizard, to be followed by snakes, frogs, and salamanders. Plans also include expanded discussions to add identification, life history and behaviour for each species; the Summary will thus become, in fact, a comprehensive Herpetology of Ontario.

Current prices for copies of volumes to date can be obtained from the Ontario Field Herpetologists, c/o M. E. Obbard, R. R. 22, Cambridge, Ontario N3C 2V4. Copies of the observation cards and instructions to contributors are also available from this address on request.

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Atlas des amphibians et des reptiles du Quebec 1988-89. Version preliminere

Compilé par J. Roger Bider et Sylvie Matte. 1990. Société d'Histoire Naturelle de la Vallée du St-Laurent, Ste-Anne-de-Bellevue, Quebec, et Ministere du Loisir, de la Chasse et de la Pêche, Direction de la Gestion des Espèces et des Habitats, Service des études écologiques, 150, boulevard St.-Cyrille Est, Québec, Québec G1R 4Y1.

Atlas des amphibiens et des reptiles du Quebec. Version detailes

Compilé par J. Roger Bider et Sylvie Matte. 1991. Société d'Histoire Naturelle de la Vallée du St-Laurent, Ste-Anne-de-Bellevue, Québec, et Ministère du Loisir, de la Chasse et de la Pêche, Direction de la Gestion des Espèces et des Habitats, Québec, Québec.

Roger Bider has been a active force in Quebec natural history since the mid-1950s. His initial apprenticeship as summer assistant to the turtle surveys of J. E. Mosimann, then at the Université de Montréal, solidified his interest in reptiles and amphibians. Bider went on to develop sand-track plots particularly for assessing the numbers and activity of small mammals and has also authored studies on birds, but has continued to return repeatedly to papers on reptiles and amphibians, and especially on the ecology of turtles. He has been a prolific researcher, graduate student supervisor, and teacher at MacDonald College of McGill University since the 1960s. In addition, was a founder of the St. Lawrence Valley Natural History Society, and was instrumental in establishing its Ecomuseum.

In the atlas project he is joined by an able collaborator and former student Sylvie Matte (B.Sc. 1987 from McGill in Wildlife Resources). Funding was provided by the Ministère du Loisir, de la Chasse et de la Péche. The latter has increasingly supported surveys and reports on ecological and utilization data for amphibians and reptiles in Quebec and thus made a major contribution to their study and future conservation in the province.

One atlas objective was to encourage herpetologists and naturalists in Quebec to contribute recent observations. In this, the project was largely modeled after the highly successful Ontario Herpetofaunal Summary. There are differences, however. The Ontario project started with the concept of producing publications of the data by year, and adding at some future time historical distribution from museum collections, publications, and archival field notes. The Quebec one started with a survey of existing collections and then called for public participation. The Ontario project started as hand compilations and computerized later, although now virtually the entire data set is on D-base. The Quebec records were computer entered on diskette from the start and transferred in 1991 to a permanent retrievable data bank D-base program. Whereas the Ontario project was envisioned as continuing at least for five successive years, the Quebec one was financed initially for one and then extended. Both have broadened in scope, with success.

Starting in 1988, Quebec standard observation cards were distributed to all who volunteered to contribute. The initial response was excellent, 177 contributors in 1988, but only 74 in 1989, though the number of observations per observer went up indicating that the most enthusiastic continued to assist the project and expand their contribution. Record totals are 4969 pre-1988, 875 from 1988, 661 from 1989, and 800 from 1990. The use of the data from collections, references and observation cards of the National Museum of Natural Sciences (now the Canadian Museum of Nature) provided about 5000 entries. Data on other museum collections were provided by the Royal Ontario Museum and the Carnegie Museum, Pittsburgh, Pennsylvania.

The bulk of each atlas is individual accounts for the 34 native freshwater and/or terrestrial and the one marine species. The latter is the Tortue luth (Leatherback Turtle) *Dermochelys coriacea*, recorded in the Gulf of the St. Lawrence. Two introductions or escapes; Tortue a oreilles rouge (Red-eared Slider), *Chrysemys* [= *Pseudemys*, = *Trachemys*] *scripta*; Tortue tabatiere (Box Turtle), *Terrapene carolina* are also given individual accounts in the 1990 edition; in the 1991 version they are combined with L'iguane commun, *Iguana iguana*, and L'anole vert, *Anolis carolinensis*, in an introduced species section. Individual accounts of the first two had also been included in the Ontario Herpetofaunal Summary mixed in with native species.

Each species account has a brief introductory statement summarizing the range, followed by a county by county listing of all records and sources,

divided into 1990, 1989, 1988, and pre-1988 records. Latitude and Longitude, and sometimes UTM grid references, are given for many collections but neither has been worked out for every collection and apparently are included only if given in the original museum or observer entry. No catalogue numbers are cited for museum specimens, instead the collector and year of collection is given. This makes it extremely awkward to trace and verify existing specimens in the museum because collections are usually catalogued in sequence in the year received, not necessarily the year collected. Further confusion is added by the omission of the citation of the Canadian Museum of Nature for its records because of the large number of entries for this collection (other museums are cited and those museum records not credited are then the NMC ones). It is also not easy to distinguish catalogued specimens from observation cards filed in the museum in this system. Accepting all observations and collections as first entered has introduced some errors which had not been corrected at the time of compilation in the original records. For example, an observation of "*Desmognathus fuscus*" larvae in the NMC file from Gatineau Park, far west of the expected range for the species, was certainly of *Ambystoma* sp., and tadpoles first catalogued from a collector's assignment as "*Pseudacris triseriata*" from southeast of James Bay are more likely *Hyla* (= *Pseudacris* by some recent authors) *crucifer*. A further confusion occurs in the Gatineau *Desmognathus* record, perhaps due to the insistence of translating all localities and data first recorded in English into French for Atlas listing. Thus, this locality which is "Black Lake" on the original card became "Lac Blake" in the Atlas. Such lapses are, however, few.

There are two maps on which individual localities are plotted with different symbols for pre-1988 and 1988-89 (1988-90 in the more recent edition) records. One is a map of all of Quebec except the northern pinnacle (which has no amphibians or reptiles). The other, more detailed, map is of southern Quebec. The overall map in the 1990 edition had the larger lakes marked as prominent black splotches which often obscured records, but the maps have been redone and this modified for the 1991 edition. As with the Ontario Herpetofaunal Summary, there is no indication on the maps which records are verified by museum specimens and which are merely sight identifications. Like the Ontario effort, however, observers can be identified in the listed localities and hopefully can be contacted individually to verify the reliability of records included.

At the beginning of each edition of the atlas there are acknowledgments, an introduction, sections on methodology and format, a summary of the information compiled, and a list of symbols and abbreviations. After the accounts there are four pages of references (and lists of contributors for 1988 and for 1989 in the 1990 edition. There are 8 figures and 5 tables in the 1990 edition, 10 and 5 in the 1991), variously summarizing and listing areas where observations came from in different periods. The text is in French only.

The authors and contributors who put so much into producing the atlas are to be congratulated. Special praise should also go to the Ministere du Loisir, de la Chasse et de la Pêche for its support of this project as part of its wide and continuing program to obtain better data on which to soundly base conservation strategies for all animals, plants, and natural areas in Quebec.

Copies of the preliminary version are, unfortunately, no longer available, and the 1991 edition is not publicly distributed, although copies were sent to participants in the survey. This material will be used as the basis for a summary of the amphibians and reptiles of Quebec in a more general form (lacking the detail on each record but with the addition of illustrations and accounts of species) to be published in the future. Observation cards and instructions may still be obtained from Dr. J. Roger Bider, Department of Renewable Resources, MacDonald College of McGill University, 21 111 Bord du Lac, Ste. Anne de Bellevue Quebec H9X 1C0.

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BOTANY

The Names of Plants, Second Edition

By D. Gledhill. 1989. Cambridge University Press, New York. vi + 202 pp., illus. Cloth U.S. $44.50; paper U.S. $14.95.

The first edition of this book was reviewed in this journal in 1987 (*Canadian Field-Naturalist* 101: 318). The second edition is somewhat expanded, particularly with regard to the glossary, which now contains many commemorative generic names, in addition to names that are descriptive of plant morphology, habitat preference, or distribution. Discussions have also been added on several aspects of the *International Code of Botanical Nomenclature* and the *International Code of Nomenclature for Cultivated Plants* that were not dealt with in the first edition, including comments on synonymous and illegitimate names.

The aims of the second edition remain the same as they were for the first edition; namely, to provide interesting accounts of the history and procedures of naming plants, and the meanings of plant names. The scope has also remained the same, except for the enhanced discussions and glossary. By way of a brief summary, the book contains chapters on the history of plant naming systems, the reasons for developing a system of rules for naming plants, details on some of those rules, and a glossary of names.

The main body of the text is written in such a way that it should be understandable to virtually anyone with even a mild botanical interest. A few basic points about the construction of names that relate to Latin grammatical rules are included, but the technical details of Latin grammar and the intricacies of the rules of nomenclature are not dealt with. The reader is referred to other sources for such technical details.

The glossary forms the largest part of this book, and contains many generic and specific names, along with their derivations and meanings, if known. The emphasis is on Eurasian plant names, but many of these are relevant to the North American flora, so this book will also be useful here. In spite of this Eurasian bias, at least one name in the glossary has been given only a North American derivation, even though a European derivation also exists. The name is '*nevadensis*', which may refer to either the Sierra Nevada of California or of southern Spain. Surprisingly, the Spanish mountain range was overlooked.

Although the basic text remains similar in the second edition, additions and improvements in organization (e.g., more sub-headings) have been incorporated. I have few complaints with the text. There are occasional points that require clarification. For example, a brief discussion of recent Eastern European usage of family names notes that these botanists use alternative names and concepts. However, there is no explanation of why this has happened, and whether or not this is permissible under the *Codes*.

A comparison of the old and new text shows that most of the errors in the old version have been corrected. However, several new typographical errors have crept in. There are enough of these (43) to be distracting. This is nearly twice the number of typos that occurred in the first edition, suggesting that the publisher and author were in a hurry to get the second edition off the press.

My major complaint with the first edition related to the lack of adequate cross-referencing of the illustrations with terms in the glossary. This problem has *not* been remedied in the second edition. This means that the reader who would like to examine an illustration relating to a particular term must still search through the pages of the glossary to find it.

In the final analysis, I have mixed feelings about this new edition. The contents of the book remain excellent. It is generally well written and understandable, and fulfills its aims. Nevertheless, the illustration problem still remains, and a host of new typographical errors have crept in. Had the producers of this edition taken a bit more time and care, these problems could have been easily overcome. I still recommend the book to anyone wanting an introduction to plant nomenclature: it is good material, just not carefully produced this time around.

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Mushrooms and Truffles of the Southwest

By Jack S. States. University of Arizona Press, Tucson. 224 pp., illus. Cloth U.S. $19.95; paper U.S. $9.95

This is one of the nicest local field guides I have seen recently. It has a hard cover, glossy paper, and easy-to-read text. There are ample colour photographs of excellent quality and size. Coloured illustrations of some of the species are not available elsewhere. The book is designed for naturalists in Arizona, New Mexico, and parts of Colorado, Utah, Nevada, Texas, California, and northern Mexico. Towards this goal the author has included maps of the Life Zones and Vegetation Zones of the area. However, many of the species are typically western in distribution and occur in Canada also. The guide would be a handy reference in British Columbia or Alberta.

Illustrated species of note are *Boletus barrowsii,* recently discovered in B.C., *Leccinum subalpinum, Amanita caesarea, Lactarius indigo, Lentinus ponderosus,* and *Stropharia kauffmanii,* plus the genera *Radiigera, Longula, Brauniella, Montagnea, Chamonixia, Gautieria, Melanogaster,* and many more. Several lichens and slime moulds are treated, along with polypores, puffballs, and stinkhorns. Keys to the major families are provided with page references to where the groups are discussed. Species identification is made by comparing the illustrations and descriptions which are based largely on macroscopic features.

The only item to criticize is the inverted photo of *Xeromphalina campanella*. I recommend this book to amateur mycologists in western North America, and to others in North America who wish to add to their library the interesting notes and 156 clear photos.

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Fescue Grasses of Canada

By S. G. Aiken and S. J. Darbyshire. 1990. Agriculture Canada. Canadian Government Publishing Centre, Supply and Services Canada, Ottawa. 113 pp., illus. $22.95. Also available in French.

Grasses in general have a reputation for being amongst the most difficult angiosperms to identify. The *Festuca* are one of the more challenging genera because many species have minute floral parts and very narrow leaves. This publication takes much of the tedium out of identifying the twenty-four *Festuca* species found in Canada.

This handsome publication will be appreciated by the field naturalist. Its key is based mostly on vegetative characteristics rather than minute floral characteristics. It has an excellent discussion of the important plant characteristics used in *Festuca* identification. The excellent electron and microphotographs are a pleasant surprise. Several are very helpful in showing the difference between intravaginal and extravaginal shoot morphology.

Each species has a separate detailed description of their taxonomic characteristics and a detailed discussion of the history of their taxonomic classification. Each description is accompanied by very beautiful botanical drawings by Marcel Jomphe. These detailed drawings depict many important floral and vegetative characteristics including important diagnostic details of the ligule and collar. The detailed cross-sections of the leaves depicting the location of schlerenchyma tissue will be greatly valued by physiological ecologists studying gas exchange characteristics. In addition, each species has a very nice map of its known collection sites.

This book belongs in the library of everyone working on the breeding, ecology, management, physiology, and taxonomy of the fescue grasses in Canada and the northern United States. This book is accessible to the amateur naturalist and valuable for the professional agrostologist.

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The Genus *Pleione*

By P. Cribb and I. Butterfield. 1988. The Royal Botanic Garden, Kew, England (in association with Christopher Helm, England and Timber Press, Portland, Oregon). 128 pp., illus. U.S. $32.95.

Over 30 years ago I flowered my first orchid, a specimen of *Pleione formosana*. This opened the door to a lifelong enjoyment of orchids in general and *Pleione* in particular. It was not until 1973 that I was able to get a second species but this spurred me to increase my collection. By 1977 I had managed to get to six species. This involved a lot of confusing and often amusing correspondence with Asian plant dealers. The confusion arose from their careless use of English and a fair disregard of the taxonomy of the genus. By 1980, I had decided that there were 16 possible species by using the plant dealers' lists and the limited literature.

This book finally lays most, but not all, of these problems of confusion and uncertainty to rest. The authors have painstakingly evaluated the literature (27 citations, only 20 of which are directly related to the genus), as well as live and preserved specimens and wild plants. From this they conclude there are 15 species. Each of these is described in full scientific detail, along with two naturally-occurring hybrids. They give brief descriptions of three additional and doubtful species, for which there is no authenticated material at this time. But the possibility remains that new species will be unearthed, particularly in China. Indeed the 15th species, *P. aurita*, appears as an addendum, as the specimens arrived only after the book was submitted to the publisher.

Both the natural hybrids, *P. x confusa* and *P. x lagenaria*, were cultivated as species for many years before their true identity was realised. The authors have now established the parent species with a strong degree of certainty.

The authors also describe the morphology of the genus and the best cultivation techniques. These latter include the subtle differences between each species, based on a sound knowledge of their annual cycle. It is this type of understanding that allows the grower to achieve the best plants and flowers. I can now see why I had great success with some species and others were a constant struggle.

Each species is illustrated with either colour plates or line drawings. The quality of the work is excellent but sadly the two women who drew the line drawings are neither credited nor acknowledged. (The addendum is illustrated by a man who is credited). The colour plates by Christobel King must surely come as close to the grace and delicacy of these wonderful flowers as any artist can. The artwork makes up 20% of the book and is an important contribution.

There are 30 high quality, small, colour plates of species, in cultivation and in the wild, and some recent hybrids. All the photos are by men and are credited and acknowledged.

The book ends with a list of the 44 currently known hybrids, with their parentage. Many of these only flowered for the first time in the late 1980s, indicating the relative newness of *Pleione* hybridisation. The results, as seen in the photographs, are truly charming. One wonders when the first intergeneric cross, say with *Coelogyne*, will be tried, and what marvels will result.

This is a delightful little book, whose size belies its value. It is important scientifically because it brings order and thoroughness to what was a state of confusion. It will be a standard reference for many years to come. It makes a major contribution to the understanding needed by the breeder and grower and the wonderful illustrations make it a delightful addition to any botanical library.

The authors infer that growing *Pleione* is on the rise. Since I lost my collection in an ill-timed move I have been on the lookout for a new source of plants, without success. As this is an English book it seems that *Pleione* are really only becoming more popular and more obtainable in that country — pity!

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Ecology of Soil Seed Banks

Edited by Mary Allesio Leck, V. Thomas Parker and Robert L. Simpson. 1989. Academic Press (Harcourt Brace Jovanovich, San Diego). 462 pp., illus. U.S. $75.

Our awareness of intricate reproductive processes and strategies in plants has increased dramatically over the last two decades. Stimulating texts on population dynamics, pollination biology, seed dispersal, seed ecology, and life history strategies have appeared in science libraries. The topic of soil seed banks (i.e., dormant seeds beneath or on the soil surface) is one of the contemporary areas of plant reproductive ecology to receive analytical attention and it is fortunate that we now have a text on the subject.

Leck, Parker, and Simpson have invited twenty-three contributors from the United States and Canada, and one each from England and Panama to contribute papers on one or more of sixteen topics. The topics are grouped, and accordingly divide the book into five parts; introduction, seed bank processes, seed banks and vegetation type, management and soil seed banks, and a synthesis. Each topic is an up-to-date review of the available published information. In several manuscripts, there are hints of preparation difficulties because the source information has been incomplete, often difficult to compare, and even poorly sampled. Nevertheless, the authors have put together excellent chapters that are readable, adequately illustrated, and thoroughly referenced. The single reference section near the back of the book consists of 59 pages and nearly 1500 different references!

The two-page preface by the editors commences with a recollection of the old adage "One year's seeding — seven years' weeding". A good place to start because farmers and gardeners were the first to recognise the role of the soil in the regeneration of plant populations. A reminder by J. P. Grime that the poppies in Flanders field were the result of exposure of the seed bank to germinating conditions sets the the tone for his short foreword, "Seed banks in ecological perspectives". He, and the authors of chapter one, describes how early seed bank work consisted of finding out the kinds and numbers of dormant seeds in different soils, how long the seeds can survive, and improving the methodology. The topic then progressed beyond the descriptive approach to one of seed bank classification, and then to an analysis of their dynamics.

The introduction (the first five chapters), describes in more detail the dynamics of seed banks. Unfortunately, there is no chapter specifically on how seeds get into the soil — the bank deposit (i.e., seed dispersal and the "seed rain"); but the cash withdrawal — kinds of dormancy and dormancy breakage is well covered. The role of seed herbivores (bank robbers?) is emphasized, as is their determination of the make-up of seed banks, and how they have shaped the evolution of seed bank strategies. The final chapter in this section describes how predictive modelling can be used, if only we had a sufficiently sound data base.

Part three describes the seed banks of eight different sets of biomes; arctic/alpine, coniferous forests, temperate deciduous forests, tropical regions, grasslands, California chaparral/Mediterranean shrublands, deserts, and wetlands. Each author(s) has used their/his/her own format to describe the state of knowledge for that study. Several themes recur in these texts: (i) The proportions and diversity of species in the seed bank rarely correspond to those of the above-ground vegetation. (ii) Very little is known about seed banks and their dynamics, especially in arctic/alpine and tropical systems. (iii) Seed banks are most extensive in the early stages of succession, or where there is frequent disturbance. (iv) Seed banks are especially well developed after fires in coniferous forests and chaparral vegetation, where they are just one of several survival strategies (which include serotiny, spouting, and dispersal). (v) Few shade-tolerant, large-seeded, or woody species are represented in seed banks.

Part four describes how seed banks can be manipulated in artificial or in natural plant communities, to discourage undesirable species or to encourage those that are preferred. This section is well written and has considerable application. For instance, ideas are provided on how to tackle serious weed problems in arable lands or in wetlands. In addition, there are enlightening discussions on the manipulation of environments to enhance certain floristic features (e.g., in marshes), or to help preserve rare species or communities.

Finally, in Part five, the editors write a synthesis for the book in order to interrelate its various components.

In my view the book is an excellent addition to any science library and will likely be an internationally important text on this intriguing topic for many years to come.

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ENVIRONMENT

Gaia: The Growth of an Idea

By Lawrence E. Joseph. 1990. St. Martin's Press, New York. 276 pp. U.S. $19.95; $27.95 in Canada.

Anyone interested in the conservation of our planet should become acquainted with the "Gaia concept." Named for a Greek Goddess roughly equivalent to "mother earth", the Gaia concept hypothesizes that our planet Earth behaves as a self-regulating organism with an outer membrane. As a corollary, the evolution of living organisms and their environment is an inextricably coupled process with feedback mechanisms. Such biological homeostasis is nicknamed "Daisyworld."

Lawrence Joseph gives us a balanced historical account of the development of the Gaia and "Daisyworld" concepts by the eccentric British genius, James Lovelock, whose greatest invention, in 1957, was the electron capture detector (ECD). The ECD allowed detection of chemicals such as DDT in part per trillion and made possible Rachel Carson's 1962 landmark book, *Silent Spring*. In 1971-72 Lovelock and two collaborators on a voyage to Antarctica used Lovelock's homemade gas chromatograph to measure gases in sea and air. They were the first to demonstrate that indestructible chlorofluorocarbons (CFCs) were accumulating worldwide — but three times as common in air blown from Europe as from the open sea. Lovelock also discovered that tiny ocean phytoplankton release the dimethyl sulfide that rises into the atmosphere and, transformed into condensation nuclei, aids cloud formation and transports needed sulfur to land.

To Lovelock and his co-worker, bacteriologist Lynn Margulis, symbiotic cooperation between organisms is more important than competition. Margulis has studied bacteria that desalinate tidal pools, varnishing salt so that it can't redissolve; lipids secreted by the bacteria in turn reduce the impact of waves that crash onto the lagoon. Lovelock believes that self-regulating systems have maintained the earth's oxygen at an ideal 21% and the ocean at optimal salinity over 500 million years. Biodiversity has practical survival value; destruction of marine life would destroy the earth's thermostat.

Our ozone layer, part of the protective membrane around our planet, is threatened by CO_2, by CFCs, and by methane. Biologists studied termites without appreciating the amount of methane they released, while upper atmosphere scientists noticed the methane there but didn't realize its origin. Lovelock's approach ties everything together. Lovelock, although he invented the instruments and designed the experiments to show the hazards of CFCs, which deplete the stratospheric ozone layer, at first had too much faith in Gaia's self-regulating ability.

Lovelock draws our attention to the dangers of the "four Cs: cars, cattle, chainsaws, and coal." He fears the ill-effects of agriculture (cows pass a lot of methane) as much as those of industry. He stresses that nuclear energy is environmentally friendly as compared to coal as an energy source.

We can benefit from opening our horizons even if the Gaian concept is as much metaphor as science. Read Lawrence Joseph's interesting account and decide for yourself. We violate Gaia, mother earth, at our peril.

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Dynamic Biogeography

By R. Hengeveld. 1990. Cambridge Studies in Ecology, Cambridge University Press, New York. xiv + 249 pp., illus. U.S. $54.50

Dynamic biogeography is defined by the author as the analysis and understanding of spatial biological phenomena in terms of past and present factors and processes. This broad subject was approached with the condition of being "very much a personal synthesis". Although this is an interesting perspective, it makes for a book that is neither novel nor comprehensive. The format of the book takes a top-down approach of exploring species' distributions by first examining broad-scale biogeographic patterns and processes, and then finer-scale phenomena.

The book reviews a selection of methods used in biogeographical classification. This review is not exhaustive, and the discussion of the methods varies from a detailed explanation of cluster algorithms to a brief comparison of ordination techniques. Despite an attempt to avoid a "cookery book", the author falls into the trap of limiting the readers' options by limiting the number of methods discussed. One interested in quantitative methods of biogeographical classification would be better served by more extensive works such as Ludwig and Reynold's *Statistical Ecology* (1989).

The remainder of the book examines geographical trends at various scales from species richness to intraspecific variation; areography (the analysis of species ranges); and, the dynamic structure of species ranges. These topics are surveyed largely through a series of interesting examples. However, a more detailed discussion of the concepts underlying

these examples, as provided in Myers and Giller's *Analytical Biogeography* (1988), would have been useful. On an editorial note, a glossary of the biogeographical terms used in the text would benefit the readers. Scientific names are often presented without a common name or any indication of type of taxon being discussed. Captions often inadequately explain the figures, and legends (e.g., Figure 36, p. 137) and units of measurements (e.g., Figure 19, p. 85) are frequently missing on the figures.

The author succeeds in demonstrating that the dynamic nature of species distributions is integral to the understanding of biogeographic processes and the explanation of biogeographic patterns. However, he fails to formulate a comprehensive dynamic model of species distributions. This book has many shortcomings, but the lack of stimulating ideas is not one of these. The Cambridge Studies in Ecology series is aimed at upper-level scientists, and *Dynamic Biogeography* will appeal to only those with the keenest interest in this subject.

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Mathematical Modelling in Ecology: A Workbook for Students

By Clark Jeffries. 1989. Birkhauser, Therwil, Switzerland. x + 193 pp., illus. SFr 49.50.

This book introduces ecology students to the construction of dynamic models (models which change with time) to describe stable ecosystem development in terms of energy flow. The approach is to study deterministic models and then to look for the same patterns in nature. The author assumes a background in differential calculus and liner algebra. Systems of difference equations are introduced in the first chapter. More advanced mathematical topics are covered as examples of more realistic models are developed. Some of the advanced topics include Lyapunov theory, linearization theorem, Hurwitz stability test, matrix methods, digraphs, attractor region theorem, and chaotic dynamics.

This is not a cookbook of ecological modelling. There are no examples of large ecosystem models to serve as templates for other projects. Rather, the emphasis is on mastering several key mathematical concepts used in modelling. This is made more palatable for the ecology student by its presentation in an ecosystem context.

Each concisely written chapter is followed by a set of exercises and explanatory answers, to the relief of many students frustrated by other modelling texts. Many of the exercises are drills in mechanical skills. These drills give the beginner ample opportunity to develop the skills needed to understand modelling. Then the beginner can fairly assess the potential of mathematical modelling to serve as a framework in which to organize knowledge about ecosystems.

Many of the exercises require a microcomputer. Example programs are listed in BASIC, LOTUS, and for a Hewlett Packard 41 CV calculator. Beware, at least one program contains a typographical error that prevented the program from running.

The small size of this well illustrated book is deceptive. The novice will need to spend an ample amount of time doing the exercises in order to fully understand the material. Each exercise set takes two to six hours to complete. This book can serve as a good textbook for upper division undergraduate and graduate courses in ecosystem modelling.

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At the Water's Edge: Nature Study in Lakes, Streams, and Ponds

By Alan M. Cvancara. 1989. John Wiley and Sons Inc. 232 pp., illus. U.S.$10.95.

Cvancara, a Professor of Geology and author of *A Field Manual for the Amateur Geologist,* shows further expertise as he thoroughly explores the various types of freshwater environments and their unique characteristics.

The content of the book is well researched, very readable and the format allows quick and easy reference. Though primarily directed at the aquatic naturalist, it can be of great value to parents and children, or any outdoor enthusiasts.

Initially you are introduced to "Water, The Elusive Substance", its composition, the different forms it takes, and the formation of water molecules. After the reader has obtained this basic understanding, Cvancara delves into the subject matter with such topics as flora, fauna, aquatic life, and seasons in a manner that educates and arouses the interest of the reader.

The inclusion of correct pronunciation for difficult or uncommon words is useful as is the chapter on taking field notes and recording observations. Unfortunately, Appendix A, the Listing of Selected National Wildlife Refuges to observe freshwater and shorelife, would not be used frequently by Canadian naturalists as it is restricted to American locations. It would however, be an invaluable source of reference for those planning vacations in the United States.

There is a chapter specifically dealing with shorelines, canoeing, kayaking, and snorkelling; activities which allow one to more fully appreciate these areas, complete with manuevering techniques and safety tips. The author's valuable addition of hints allows the reader to better observe underwater life and aquatic plants and answers important questions like when, where, and what to look for. A great deal of emphasis is evident throughout the book on an "all senses" approach to enjoying and learning about our natural environments.

Of prime concern to all people who enjoy the outdoors and often spend time in or around the water, is pollution. "Bad, Bad, Water" is briefly discussed, touching on causes, effects, and prevention, but most importantly the emphasis is on observation and recognition of the characteristics of bad water and the safety of its users.

Surrounding the text are useful diagrams and numerous black-and-white photographs. It should be noted that the absence of colour does not detract from the book, but in many ways enhances it. The macro photos are examples of when black-and-white photography can add to the simplicity of composition and in this case was an ideal choice that complements the text.

A deeper understanding of things can no doubt be dramatically assisted by the value of experience. In view of this, the last chapter is a hypothetical, three-day solo kayaking trip allowing the reader to vicariously hear, see, smell, taste, and touch through the excellent writing style and descriptive text. This provides an entertaining and enjoyable conclusion to an interesting study of freshwater.

A good example of the author's feelings are evident in this statement at the conclusion of this imaginary excursion;

"The end of the journey nears, and I feel saddened — as always. For here I live more fully and sensitively than within society, and accumulate fundamental life-lasting experiences. As I continue to learn, my awareness intensifies."

Physically the book is larger than the average field guide and not the type you would pack along. Its value however, lies in the initial reading, then the reviewing of pertinent sections prior to a particular excursion or for reference purposes. In this sense it is a good introduction to freshwater environments and a valuable addition to a naturalists' home/reference library.

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Ecological Experiments: Purpose, Design, and Execution

By Nelson G. Hairston, Sr. 1989. Cambridge Studies in Ecology, Cambridge University Press, New York. xiii + 370 pp., illus. Cloth U.S. $52.50; paper U.S. $24.95.

Hairston is the "H" in "HSS", the 1960 paper by Hairston, Smith, and Slobodkin that is one of the few ecological papers with enough fame (or enough notoriety) to have its own acronym. It was a strong argument on behalf of the density-dependent school of thought about the organization of ecological communities, in support of the idea that competition and predation operate to maintain a balanced state among decomposers, producers, herbivores, and predators. This present book is mainly a compilation of evidence from field experiments that are relevant to HSS. It is not primarily about experiments as such, despite the title.

Three main themes run through the book. The first is "that experimentation is necessary for progress in ecology". The book begins with a clear statement of some common-sense rules for doing experiments, especially under the constraints of field conditions. There is little discussion of either the statistical or the philosophical grounding of these rules, and it is not always clear what is essential and what is mere conservative tradition. Nevertheless the standard of science in ecology would improve if we all read these first three chapters periodically. The author gives examples of both good and bad experimental practice in the ecological literature, naming names in both cases.

The second theme, more controversial, is that "each kind of environment should be considered separately, because there are few, if any, specific statements about ecological processes that will be true across all environments". The evidence in the book is arranged by type of environment, with one chapter for each of forests, terrestrial successional communities, arid environments, fresh water, and marine environments. There are further subdivisions within chapters.

The third and most important (although not explicit) theme is that ecological systems are organized primarily by biotic interactions, and that they are, by and large, stable and balanced. A small but telling indication of this is in the subject index. "Competition" gets many dozens of entries, while "disturbance" gets just four. The basic outlook is essentially that of the density-dependent school of the 1950s. Whether this is appropriate for a current ecological book, and whether it is useful to pursue what is essentially an ideological dispute into its

fourth decade, is not obvious to me. The evidence amassed here is important, but it needs to be read with more than usual attention to the unstated background assumptions.

In summary, this is a curious but useful book, suitable for a much narrower audience than implied by its title.

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The Ecology of Intercropping

By John Vandermeer. 1989. Cambridge University Press, New York. xi + 237 pp., illus. U.S. $59.50

John Vandermeer wrote *The Ecology of Intercropping* with a dual purpose in mind. The first purpose was "to suggest to the ecologist that intercropping might be a rich laboratory for testing ecological theory". The second purpose was "to suggest to the intercropping researcher that ecology might offer a framework within which an already strong empirical program might make more sense".

The statement of purpose would suggest the book was not written for an individual without some experience or knowledge of research methods or ecological theory. I found some knowledge of competition, specifically, would be an aid in understanding some of the theories discussed.

Dr. Vandermeer has organized his book in a clear, logical manner. The chapters have been written to lead one, step by step, through the theoretical thought process to the present state of intercropping theory. Examples have been supplied from his own research efforts as well as work from other researchers, to help clarify or establish the appropriate groundwork. The final chapters discussed models and "critical" research directions.

The author, in his own words, did not attempt to provide an extensive literature review of the subject matter but I feel he managed to provide an adequate summary of literature available on the subject. Pertinent citations were found throughout the book.

In summary I feel the author has managed to provide reasons (1) for the ecologist to consider intercropping as one of many methods for testing ecological theory, and (2) for the intercropping researcher to consider an ecological framework, in this well organized publication. The book should be of interest to both ecologists and intercropping researchers.

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NEW TITLES

Zoology

*__Analysis of wildlife radio-tracking data.__ 1990. By Gary C. White and Robert A. Garrott. Academic Press, Troy, Missouri. xiii + 383 pp., illus. U.S.$59.95.

*__Anatomy of a controversy: the question of a language among bees.__ 1990. By Adrian Wenner and Patrick Wells. Columbia University Press, New York. 339 pp. U.S.$63.50.

†**The biology of the naked mole rat.** 1991. Edited by Paul W. Sherman, Jennifer U. M. Jarvis, and Richard D. Alexander. Princeton University Press, Princeton. xvi + 518 pp., illus. Cloth U.S.$65; paper U.S.$24.95.

*__The birds of British Columbia, volume 1: nonpasserines introduction, ornithological history, the environment, and species accounts (loons through waterfowl) and volume 2: nonpasserines diurnal birds of prey through woodpeckers.__ 1990. By R. Wayne Campell, Neil K. Dawe, Ian McTaggert-Cowan, John M. Cooper, Gary W. Kaiser, and Michael C.E. McNall. Royal British Columbia Museum and Canadian Wildlife Service, Victoria. xvii + 514 pp., illus. + 633 pp., illus. 2 volumes $99 + $8 shipping.

*__The birds of Japan.__ 1991. By Mark A. Brazil. Smithsonian Institute Press, Washington. 400 pp., illus. U.S.$49.95.

†**Birds of the lower Colorado River Valley.** 1990. By Kenneth V. Rosenburg, Robert D. Ohmart, William C. Hunter, and Bertin W. Anderson. University of Arizona Press, Tuscon. 464 pp., illus. U.S.$40.

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The development and evolution of butterfly wing pattern. 1991. By H. Frederick Nijhout. Smithsonian Institute Press, Washington. 336 pp., illus. Cloth U.S.$45; paper U.S.$20.

Diptera types in the Canadian national collection of insects, part 1: Nematocera. Canadian Government Publishing Centre, Ottawa. 120 pp. English; 113 pp. French. $20.95 in Canada; U.S.$25.15 elsewhere.

*__The evolution of parental care.__ 1991. By T. H. Clutton-Brock. Princeton University Press, Princeton. xiii + 352 pp., illus. Cloth U.S.$49.50; paper U.S.$19.95.

Exploring the world of birds. 1990. By Adrian Forsyth and Laurel Aziz. Camden, Charlotte, Vermont. 72 pp., illus. Cloth U.S.$15.95; paper U.S.$9.95.

*__Field guide to freshwater fishes North America north of Mexico.__ 1991. By Lawrence M. Page and Brook M. Burr. Houghton Mifflin, New York. xii + 432 pp., illus. + 48 plates. Cloth U.S.$24.95; paper U.S.$15.95.

Fish. 1990. By Steve Parker. Knopf, New York. 64 pp., illus. U.S.$14.99.

*__Interpretation and explanation in the study of animal behavior, volume 1: interpretation, intentionality, and communication; volume 2: explanation, evolution, and adaptation__. 1990. Edited by Marc Bekoff and Dale Jamieson. Westview, Boulder, Colorado. xxx + 465 pp., illus. U.S.$45 each.

†**The natural history of shrews.** 1991. By Sara Churchfield. Cornell University Press, Ithaca. xiv + 178 pp., illus. U.S.$32.95.

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Prodigious birds: moas and moa-hunting in New Zealand. 1991. By Atholl Anderson. Cambridge University Press, New York. 280 pp., illus. U.S.$79.50.

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The ecology of Mycorrhizae. 1991. By Michael F. Allen. Cambridge University Press, New York. c200 pp., illus. Cloth cU.S.$80; paper cU.S.$24.95.

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Global alert: the ozone pollution crisis. 1990. By Jack Fishman and Robert Kalish. Plenum, New York. xviii + 311 pp., illus. U.S.$24.50.

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The living forest. 1990. By Peter K. Schoonmaker. Enslow, Hillside, New Jersey. 64 pp., illus. U.S.$13.95.

Northwest weeds: the ugly and beautiful villains of fields, gardens, and roadsides. 1990. By Ronald J. Taylor. Mountain Press, Missoula, Montana. vi + 177 pp., illus. U.S.$11.95.

Orchid biology: reviews and perspectives, V. 1991. Edited by Joseph Arditti. Timber Press, Portland. 432 pp., illus. U.S.$58.

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*__The rare vascular plants of Prince Edward Island.__ 1991. By Robin Day and Paul M. Catling. Syllogeus No. 67. Canadian Museum of Nature, Ottawa. 65 pp., illus. $4.95 plus shipping and tax.

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Environment

The acid rain debate: science and special interests. 1991. By Bruce A. Forster. Iowa State University Press, Ames. 192 pp., illus. Cloth cU.S.$22.95; paper cU.S.$13.95.

At odds with practice: Americans and conservation. 1991. By Bret Wallach. University of Arizona Press, Tuscon. 250 pp. U.S.$24.95.

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†**The ecology of desert communities.** 1991. Edited by Gary A. Polis. University of Arizona Press, Tuscon. 450 pp., illus. U.S.$49.95.

Interspecific variation in the social systems of wild vertebrates. 1991. By Dale F. Lott. Cambridge University Press, New York. c230 pp., illus. cU.S.$49.50.

Iowa's state parks: also forests, recreation areas, and preserves. 1991. By Robert C. Wolf. Iowa State University Press, Ames. 184 pp., illus. Cloth cU.S.$19.95; paper cU.S.$12.95.

Land degredation: development and breakdown of terrestrial environments. 1991. By C. J. Barrow. Cambridge University Press, New York. c300 pp., illus. cU.S.$80.

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†**Man in the landscape: a historic view of the esthetics of nature.** 1991. By Paul Shepard. Texas A & M University Press, College Station. 336 pp., illus. U.S.$2.50.

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Nature reserves: island theory and conservation practice. 1990. By Craig L. Shafer. Smithsonian Institute Press, Washington. 208 pp., illus. Cloth U.S.$39.95; paper U.S.$15.95.

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†**Peterson first guide to rocks and minerals.** 1991. By Fredrick H. Rough. Houghton Mifflin, New York. 128 pp., illus. U.S.$4.95.

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Albatrosses of Midway Island. 1990. By Sylvia A. Johnson. Carolrhoda, Minneapolis. 47 pp., illus. U.S.$12.95.

Amazing frogs and toads. 1990. By Barry Clarke. Knopf, New York. 31 pp., illus. U.S.$6.95.

Amazing poisonous animals. 1990. By Alexandra Parsons. Knopf, New York. 31 pp., illus. U.S.$6.95.

Backyard scientist, series three. 1990. By Jane Hoffman. Backyard Scientist, Irvine, California. 52 pp., illus. U.S.$9.50.

The hidden life of the desert. 1990. By Thomas Wiewandt. Crown, New York. 38 pp., illus. U.S.$13.99.

Life in the polar lands. 1990. By Monica Byles. Watts, New York. 32 pp., illus. U.S.$11.40.

Life in the rainforests. 1990. By Lucy Baker. Watts, New York. 32 pp., illus. U.S.$11.40.

Lizards. 1990. By Claudia Schnieper. Carolrhoda, Minneapolis. 48 pp., illus. U.S.$12.95.

Oceans: a fact-filled coloring book. 1990. By Diane M. Tyler and James C. Tyler. Running Press, Philadelphia. 127 pp., illus. U.S.$7.95.

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Rain forest secrets. 1990. By Arthur Dorros. Scholastic, New York. 40 pp., illus. U.S.$13.95.

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